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ENGLISH NOTES

DEVOTED TO THE INTERESTS
OF TEACHERS OF ENGLISH
IN ENGINEERING SCHOOLS

J. L. VAUGHAN, EDITOR

THE CARNEGIE FOUNDATION
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ECONOMIC AND SOCIAL STATUS OF THE ENGINEERING TEACHER*

AN OUTLINE OF IDEAS

BY PAUL CLOKE

Dean, College of Technology, University of Maine

I, therefore, propose that S. P. E. E. should address itself seriously to this opportunity, as the time is ripe, and initiate proper procedures so that the subject may be brought before the society for debate and discussion, and A PLAN OF ACTION ADOPTED.

The teaching profession is notorious for being one in which pay and salaries are, generally speaking, low. The fundamental reason for this probably lies in the mistaken belief, which many have, that almost anyone is able to teach. As further evidence of this general attitude on the part of the public, witness such terms as "Brain Trusters," etc.

Evidence is seen on every hand that technical and engineering education in the United States is rapidly getting out of its swaddling clothes. The issues, if there really were any, between the classicists and the engineers have rapidly approached the vanishing point. The objectives and aims of engineering education and the work of the engineer are being more clearly recognized. The engineers of the future will undoubtedly come almost exclusively from the engineering schools and universities and the technical colleges. The engineering teacher, therefore, occupies a strategic position in the modern world. In the hollow of his hand, I think it not presumptuous to say, lies the future welfare of modern society; at least in very great degree.

Care must be exercised so that the proper personnel is secured to staff the various departments of instruction, particularly the engineering departments. The keynote of the society during the past year has been the spiritual adjustment of the engineering student. In time, of course, this would reach the teachers as the young men develop. For the present, anyway, we must aim directly at the teachers. Perhaps we could do no better than to refer

* To be presented at the 45th Annual Meeting, S. P. E. E., Cambridge, Mass., June 28–July 2, 1937.

him to a contemplative, continued study of the Sermon on the Mount. Surely it gauges the full measure of a man. What better development can a man have than the attainment of deep understanding sympathy for his fellows; than the desire and the will and determination to alleviate the sufferings of a world still shackled in too great degree with the bonds of tyranny, injustice, prejudice, and greed?

Personalities, however, cannot be developed by precepts or instruction. We can be made aware of the rules of good conduct and ethics. Whether we will follow these or not is entirely a question of the individual. As Carlyle once said, "You cannot expect to dream yourself into a character; you must hammer and forge yourself one." What has just been said applies with equal cogency to the development of teaching technique.

I believe that there are three principal lines of development open for the engineering teachers. These three conceptions are more or less mutually dependent and interrelated. To begin with no one can be a good teacher, in my opinion, who does not have a sincere and abiding interest in the welfare of his students. Success in teaching begins with this pivotal idea. Beyond that are the three lines of development alluded to above. They are teaching ability, research, and public service. It will be immediately argued by some that teaching ability or research ability or any kind of ability cannot be taught. Quite so, but assuming that we start with an embryo teacher; by what sign shall we know him and how shall we proceed to develop him? Precisely along the lines indicated. A teacher must be constantly studying. He must come in contact with other men in his profession. He must study in other institutions. He must needs have practice in industry as opportunity affords. Industry must realize that the engineer is very necessary to it and coöperate in this latter endeavor of the engineering teacher. The mark of attainment in this first objective is probably the advanced degree.

Research of *some* kind should be undertaken by every engineering teacher. It will, in most instances, probably be in the realm of materials or applied sciences. In case one is not interested or not gifted along lines of physical research, he is by no means restricted to these fields, as many others present themselves; as research in the realm of educational ideas. Another very fertile field is city zoning and planning with their attendant problems in social trends—a very proper field for the engineer.

Institutions should draw up well defined plans as to patent rights, etc., both as regards the engineering teacher and also in regard to coöperative researches with industry.

Public service is a new word for the engineering teacher. It,

however, should be, as this is, one of the most potent means at his command to direct attention to the importance of his work and that of the engineer to society. This is a very fine outlet, also, for the flow of esthetic and spiritual feeling on the part of the individual. The range of activity is all the way from participation in the work of professional societies to church work, clubs, boy scouts, and the like. It would involve possibly executive duties, public addresses and the like.

The reader clearly realizes, I think, the marvelous opportunities that such a program presents to the ambitious teacher. On the other hand, it presents also a clearly defined objective, and so constitutes a very real measure of the development of the individual in the eyes of his students and colleagues.

If it becomes evident that advancement will be determined according to the unfolding of personality and ability as above envisaged, then those entering this profession and field of endeavor can look forward with confidence to a full measure of success, taking this work to include the development of a full and complete life, financially, mentally, spiritually, and morally.

Ideas, however, while they may be excellent, and inspiring, get nowhere by themselves. They must have an outlet and channel for action. I am convinced that the matters presented above need attention now and will need greater attention in the future. The E. C. P. D. is gradually working out an admirable plan for the development and fruition of the practicing engineer. This group, while of necessity embracing engineering educators in its membership, has not so far proposed any definite plan for the development of the engineering educator. It is evident that such a plan would contain much in common with the present E. C. P. D. plans for the engineer. It is questionable, however, if E. C. P. D. is the proper body to intitiate and develop such procedures. Rather the S. P. E. E. is the logical and qualified organization. The various committees would doubtless contain representatives from practice as well as education.

SOME LABORATORY TECHNIQUE DEMONSTRATING KIRCHOFF'S LAWS

By R. W. AHLQUIST

Assistant Professor of Electrical Engineering, University of Pittsburgh

In comparing the time that the average student in electrical engineering spends on circuits dealing with Ohm's and Kirchoff's Laws, it is found that there is considerable disparity between the classroom and the laboratory. A checkup of recent laboratory manuals reveals very little space devoted to the study of the fundamentals as laid down by Kirchoff. By contrast a number of classroom texts contain abundant material and problems based on these laws. Possibly there are several reasons for this. A relatively simple circuit of the classroom becomes a complex system of connections in the laboratory unless all parts are simplified as much as possible. The measurement of current in several branches requires ammeters of more than ordinary precision and meters that are calibrated at frequent intervals. Resistance changes due to temperature may present serious effects. These three sources of error combined with other minor ones make it imperative in laboratory experiments of this nature to remove or reduce them at their source.

At the University of Pittsburgh each junior electrical engineering student is expected to have part in the performance of a number of experiments dealing with networks. Some of these experiments will be circuits in which the voltage and current relations may be found by application of Ohm's Law, others being circuits which will necessitate the use of Kirchoff's laws. As an example of the latter, a group in the direct current laboratory is given a diagram showing five known resistors forming an unbalanced wheatstone bridge network. The voltage across the network is to be 100 volts. The group is asked first to calculate the current in each branch of the network at this voltage. After these currents have been calculated, checked, and recorded, the students are given the resistors and actually measure the currents. If enough of the sources of error mentioned above have been eliminated or have been kept small the results will check closely enough so that the student will have confidence in his calculations. No attempt is made to obtain accuracies from portable meters which are only possible with other types. However, measurements within a few per cent are well

within reason. Before starting the experiment, the probable sources of error are pointed out, showing which ones have been eliminated and which ones will affect the results.

The resistors used are of the tubular type with an Edison base. Portable boards with sockets are provided. The rating of each resistor is 100 watts. The value of each resistor will have some fixed value between 10 and 60 ohms. The temperature coefficient is small, being about .00022 at 20° C. Thus the resistance change over the working range is quite small. The cost of these units is moderate and enough of them can be purchased for $20.00 to equip all of the necessary experiments. The resistors are small enough so that they occupy very little storage space. With these resistors different circuits or different resistors can be supplied to each individual laboratory group.

In order to simplify the circuit and reduce meter errors only one meter is used to measure currents. Fifty millivolt shunts ranging from 1 to 5 ampere capacity are placed at the points where a measurement of current is desired. The values of the currents may be found by moving the leads of the millivoltmeter from shunt to shunt. If it is desired to use only one meter with the experiment a suitable multiplier can be used with the millivoltmeter taking the place of the voltmeter. Thus by the use of shunts the number of meters involved can be reduced to two or if desired to only one. This procedure makes it possible to correlate problems of the classroom and the laboratory by simplification of equipment and the elimination of some major sources of error.

ENGINEERING SENSE WITH DOLLARS

By R. C. GORHAM

Associate Professor of Electrical Engineering, University of Pittsburgh

Many statements have been written and spoken in recent years indicating a definite trend in the minds of engineering educators concerning the historical and economic content of engineering curricula. They all seem to agree that more history about engineering courses should be given to students at the time of introducing new material. One who is to teach a class the principles of a steam turbine should first tell the class something about the conception of the first steam turbine. Who originated the idea? When was it built? What was the size of the machine? etc.

Also along with history should be taught some engineering economy. More and more engineers are being required to think and figure in terms of "long-run" economy. An economic balance can be arrived at between the amount of iron and copper to be used in a transformer. A very high "nominal" efficiency can be secured for a transformer by using silver instead of iron. But who would buy such transformers if priced to yield a profit to the manufacturer? Other examples might be mentioned such as, the problem of when to add a new generating unit in a central generating station. If the unit be added one year before it is needed the company will be saddled with one year's needless fixed charges. The question of locating substations for economic electrical energy distribution is of greatest importance to the public utility or to the municipal light and power company as the case may be. For the construction engineer it can be shown by analysis that there is an economical height for an office building at a given location; there is an economical cross section for electrical conductors and an economical voltage for a feeder or transmission line.

It is believed by many engineering educators that a course could well be given embodying the general idea of "long-run" economy applied to all branches of engineering. The questions of money's worth, methods of figuring depreciation and obsolescence should probably be studied first. These subjects might be followed with problems and theories to help the engineering student use his good sense when thinking of modern engineering problems which are necessarily flavored with dollars.

Various factors can be developed for the student's use after he leaves college. However, he should learn well the special applications of certain methods of analysis. He should be able to select the proper approach for any special problem which he may meet in

his professional life. There may be a danger of getting too many factors into the economical studies where present worths, depreciation, compounding of interest, and annuities are involved. However, tables having some of these factors tabulated can become a time saver in the hands of one who works with such problems continuously.

A *correct yardstick* for comparisons is important in many instances. During the World Power Conference Mr. Muir at Schenectady showed how the rates for electrical energy have been decreasing to about three cents in the United States. But Mr. Kennedy from England suggested that United States rates are not so low because in England the rates go down to two pennies per kw. hr. To shorten a long story the two men got together and agreed on another *yardstick* for comparative purposes. They made some calculations and found that in the United States the average workman must work *one week* to pay his annual electric bill while the same type of workman in England must work *three weeks* for the same service.

The student should also realize that there is such a thing as art in engineering and that as such it has an economic application, *e.g.* new paint on public utility company's buildings improves appearances. Well kept lawns around office buildings help to build up that almost priceless asset "goodwill." How much additional cost can the designing engineer justify in "streamlining," fancy fittings and special decorations for art's sake?

We can do well to teach our students something about the system of preferred numbers in which R. E. Hellmund, Consulting Engineer of the Westinghouse Company, has pioneered. If manufacturers will get together on this system of standardizing ratings of machines and sizes of everything used in the process of manufacturing machines, many thousands of dollars can be saved annually. Students should hear about the American Standards Association and their objectives. Just who are they and why does such an organization exist?

At the University of Pittsburgh we have developed a course in the Electrical Engineering Department which has been captioned *Power Economics*. As such it has been offered as part of the prescribed curriculum to the electrical seniors for the past seven years. The course has changed some every year and is still in a formative stage. It seems that perhaps a better name for the content of the course as it exists now would be *Engineering Economy*. The mimeographed and typewritten notes make up some 200 pages of material which include about 150 problems. Are other engineering schools developing such a course or courses? Comments, suggestions, and criticisms would be welcomed by the author of this article.

ABSTRACT OF PAPER AND DISCUSSIONS *

By A. D. HINCKLEY
Columbia University

LIBERALIZING THE ENGINEERING CURRICULUM

HUMANISTIC CONTENT OF THE ENGINEERING CURRICULUM

An Example of an Integrated Program

By PROFESSOR HARRY CARMAN and PROFESSOR HORACE TAYLOR
Columbia University

The notion that society is static and fixed has long since been rejected is erroneous. We live in a changing world. Prior to the middle of the nineteenth century American civilization rested in large measure upon agriculture, commerce and handicraft. The round of daily life was confined within a narrow domestic economy with few and rare changes in social status. The overwhelming majority of our people were content to remain primitively self-sufficient. They clung tenaciously to the habitual and the customary, and distrusted innovation and change.

Since 1850, and more particularly since the Civil War which saw Southern agrarianism, resting upon a slave economy, go down to defeat at the hands of a diversified industrial Northeast and a free farming West, our civilization has rested increasingly upon science and the machine. In comparison with its simplicity of the pre-Civil War years, our civilization is now intricate and complex. Moreover, the transition from the older to the newer civilization—gradual at first, but quickening in tempo as we approach the present—has given rise to numerous insistent problems which press for solution.

And it is the presence of these problems, together with the rapidly increasing complexity of the institutions under which we live, that gives rise to an educational problem of the first importance.

It little behooves us to discuss the character of the typical course of study of the engineering school. By the very nature of its function and purpose it of necessity must place emphasis upon mathematics and the laboratory sciences. With few exceptions,

* Meeting of Middle Atlantic Section, S. P. E. E., Columbia University, December 5, 1936.

courses that give the student historical perspective and an appreciation of the pressing social-economic-political problems characterizing the age in which he lives, find no place in the curriculum of the engineering school or, for that matter, in the curriculum of those schools devoted to other professional pursuits, as for example architecture, pharmacy and medicine. And in this fact lies the danger that, with few exceptions, the engineering student will never correlate his special training with these problems.

The engineering course, as well as courses devised for other professions, should, it seems to us, be concerned with social fundamentals. It should take into account the fact that we live in a changing world and that participation in economics, political and broadly social enterprises involves responsibility, knowledge, power of analysis, and balanced judgment on the part of those who would bring direction to social change. In other words, it should give the student opportunity to gain as much knowledge as possible of the social-economic-political aspects of the civilization in which he is to function.

In recent years several engineering schools, motivated in part by the desire to introduce a bit of humanistic leaven into the curriculum, have made provision for individual or separate courses in sociology, economics or government. While the effectiveness of these courses varies greatly from institution to institution, it is our frank judgment that such courses are inadequate for giving the student that broad knowledge of our social-economic-political life which we believe to be so essential. Indeed, such courses are often little more than smattering time-wasters; and our opinion in this matter is amply supported by the testimony of both engineering students and faculty.

Instead of departmentalized courses in the so-called social sciences the student is entitled to a broad survey or orientation course which will give him, in the first place, some notion of the chief influences of the past which have conditioned the present—as, for example, the industrial revolution, the rise of democracy, and the development of the scientific attitude and procedure; and secondly, an acquaintanceship with the institutional environment, both intellectual and material, in which he lives. Economics and government often have the same problems to treat, and it is useful that students early in their career should realize that fact and learn that many problems, for their understanding and for their proposed solution, require light from many sources. The treatment of events and problems from several points of view in a single assignment is not only an educational time-saver, but brings with it an understanding far more penetrating than may be obtained from several piece-meal treatments in a variety of departmental courses.

Perhaps those who have engineering and the training of engineers close at heart will maintain that the engineering curriculum is not in need of humanizing. That point the authors of this paper do not intend to argue. Before turning to a description of what has been done in the way of an educational experiment at one institution of higher learning, we merely desire to add one further statement in support of those who believe such training to be desirable.

Increasingly business men have commissioned engineers to establish standards and to coordinate and synchronize the operations of their businesses. Increasingly too, the engineer is being called upon to collaborate with the practicing sociologist, the economist and the government official. His horizon of social usefulness continually broadens. It seems incumbent, therefore, upon those of us who are responsible for the form of his education to give him every opportunity to equip himself to the best of his ability for the functions which are certain to be demanded of him.

The subtitle of this paper refers to the Columbia College course known as "Contemporary Civilization." During the closing period of the World War several members of the Columbia College faculty organized this course as a more stable basis for the study of the contemporary world and the trends of its civilization. Inasmuch as the course was designed to fit the needs of the students in Columbia College, the undergraduate college for men in Columbia University, the committee charged with formulating the course had first to consider the character of the student body of that college. Columbia College had at that time—and as it has to-day—three types of students: (1) the student who expects to enter a professional school such as engineering, law, medicine, architecture or business, and who is pointing his entire college work toward a specialized preparation for a life of professional usefulness; (2) the student who by temperament and ambition is a scholar and for whom the college course should afford opportunity to delve deeply into some field of scholarly interest; (3) the student who wants a good education but who is interested in neither the professional school nor research work. The notion that every student to whom we give an A.B. degree is an embryo scholar is an erroneous and unwarranted assumption. In designing the course, therefore, the committee kept constantly in mind the educational needs of these three types of students and, in the long run, came to the unanimous decision that for the first two years their needs, in so far as becoming acquainted with their institutional environment was concerned, were identical.

Originally the course was limited to the freshman year, but so great was its scope and content that the job could not be done satisfactorily from the point of view of either students or staff.

Consequently the course was transformed from a one-year required course to a two-year required course, meeting five times a week throughout the freshman year and three times a week during the sophomore year.

The first year of the course deals with three important phases or factors: (1) How nature conditions man; in other words, with geographic factors in civilization—land and water bodies, river valleys, natural resources, climatic conditions. (2) The culture concept; man in society and the scene of his experiences, instruments and institutions. In this connection attention is given to such considerations as social pressure and the development of customs and instruments of physical and social control. (3) The attempt to show from 1200 down to the present something of the history of civilization in Europe and the United States, with emphasis on three main points: how men make a living, how men live together politically, and how men understand themselves and the world about them. The plan of study is chronological and the three important phases of life—economic, political and intellectual—are surveyed in successive periods from 1200 to to-day. Often the material selected is chosen because of its particular relevance to our own time and its problems. Throughout the course an attempt is made to give some notion of contemporary developments in psychology, science, literature, art and music. As modern times are approached the treatment of these subjects is somewhat fuller, but always intended to indicate cultural relationships rather than to furnish an exhaustive historical account.

Strictly speaking, this first year of the course may more properly be regarded as genetic than historical. The study of history is concerned primarily with the processes which characterize certain epochs in mankind's affairs in the past. The freshman year of the course in Contemporary Civilization, on the other hand, is focused on the institutions of the present. It seeks to show what these institutions are, by accounting for when and where they came from, and how they have changed in getting from there and then to here and now. Thus for example we study the ways in which the centralized state, controlled by an absolute monarch, came to supersede feudalism in Western Europe, the process by which absolutistic forms of government gave way to democratic forms, and the ways in which democratic forms in their turn are yielding in many places to dictatorships. But changes in governmental forms and governmental control have occurred *pari passu* with other changes. There have been concomitant changes in political philosophy, in the organization of production, in intercourse among nations, in economic doctrines, and in national and imperial policies.

Or let us consider another set of relationships which may conveniently start with a change in intellectual horizons and attitudes. The beginnings of modern physical science were accompanied by important changes in the allegiances and in the faith of men, in the trends of political and economic thought, in the organization of commerce, industry and finance, in the policies and alliances of nations, in the position of various economic classes. We attempt to treat these processes as mutually conditioning each other.

The second year of the course analyzes certain of the contemporary institutions whose genesis and development were studied during the first year. The work of the entire second year of the course is centered around the problem of economic security. Three themes are stressed: (1) What are our conditions of security and of freedom, and how may these conditions be improved? (2) What are the problems of economic life making for national self-sufficiency or leading towards international economic organization, and how do these problems affect both security and freedom? (3) What are the problems involved in enterprises freighted with public interest and in the determination of their private and public control?

Although the materials of the second year of the course fall traditionally within the special provinces of economics and government, the course does not attempt to deal with the conventional concepts of economic and political theory. At no point is there developed any theory of value or theory of the State. The first semester of the second year of the course is focused on the problem of economic security. At the outset the conditions essential to security and the conditions which make for insecurity are stressed. After examining the general problem of security, the students are given facts of national productive capacity and the distribution of the national income. They are expected to relate these facts to a conception of potential optimum use of productive resources, and to appraise prevailing standards of living according to the minimum income requirements for security at a health and decency level of living. At this point also students are acquainted, in a fairly systematic manner, with a conspectus of the current "New Deal" program and the implicit elements of that program which bear, in one way or another, upon economic security. Particular phases of this program are studied in some detail in later sections in connection with the particular economic or political situations to which they pertain. Following this introduction, with emphasis on the conditions of security or insecurity involved as well as on control and regulation, several meetings are devoted to each of the subjects: (1) organization and methods of American business, (2) organization of the system of money and credit, (3) international economic relations, (4) special problems of security which apply to agriculturists, (5) similar considerations as they apply to wage-earners.

The work of the second semester deals chiefly with remedial measures as they apply to the problems of insecurity presented during the first semester. The first topic for consideration is an analysis of the structure and functions of law and government in the United States, with special regard to the part played by courts in determining what action can be taken toward economic affairs by governmental bodies. Following this analysis of government and law we proceed to the study of (1) governmental regulation of those industries which are recognized by courts to be "affected with a public interest"; (2) the state as a spending agency and a raiser of revenues; (3) provisions against economic insecurity which have been worked out by governmental agencies—such provisions, for example, as social insurance in its current application in this country, and relief work carried on since the beginnings of the depression; (4) the coöperative movement as a means by which people have voluntarily joined in attempting to deal with certain economic insecurities, with special reference to the current growth of consumers' coöperatives in the United States; (5) alternative systematic attempts to achieve security which are being made in Russia, in Italy and in Germany (in each of these cases a conspectus of the particular nation's program is presented and the objectives served by the several programs are examined); (6) the conflicting systematic views as to political and economic organization in the United States. In this connection the student is called upon to consider a series of brief accounts of Fascism, Socialism and Communism in this country, and a systematic view of economic planning as related to the institution of a *laissez-faire* society.

Such, in brief outline, is the content of the Contemporary Civilization course. As presented in this paper one perhaps might get the impression that the content is extremely schematic and disjointed. Quite the opposite is the case; in fact, the entire course is very closely knit.

Upon what educational theory, it may well be asked, does the course rest? Our answer is simply this: In introducing the general survey course Columbia College has operated upon the assumption that it is not its fundamental business to turn out specialists in a narrow field, and that an individual is, after all, not well educated unless he or she has at least some conception of the broad field of intellectual endeavor. By this we do not mean to infer that Columbia College does not fully realize that the day has long since passed when a person could be a profound scholar in a wide field, or that the specialist is not a very useful human being in our present complex civilization. It simply means that Columbia College, where our engineering students receive part of their undergraduate instruction, is primarily concerned with liberalization rather than

with specialization, and that in addition to feeling responsible for guiding its students into particular channels it considers it even more important to help them to see as well as may be the civilization of their own day and to participate more effectively in it. We feel that we should not conclude without at least brief reference as to the manner in which the course is administered.

A syllabus for the first year, prepared by instructors from the departments of economics, philosophy, government and history, is placed in the hands of every student. This syllabus has not been built around any particular text. Moreover, it represents the combined efforts of men with somewhat diverse training and frequently of opposing points of view. Texts have been selected to fit the syllabi; these are, for the first year: C. J. H. Hayes, "A Political and Cultural History of Modern Europe," volumes I and II (Macmillan), J. H. Randall, Jr., "Making of the Modern Mind" (Houghton Mifflin), H. J. Carman and Samuel McKee, Jr., "A History of the United States," volume I (Heath), L. Hacker and B. B. Kendrick, "The United States Since 1865" (Crofts). In addition to these texts the syllabus for the first year, entitled "An Introduction to Contemporary Civilization in the West," contains considerable text material prepared by members of the staff to fit our particular needs. Two fat volumes entitled "Contemporary Problems in the United States" constitute the text for the second year. These were prepared by Professor Taylor in collaboration with other members of the instructing staff and are published by Harcourt Brace.

Instruction is on the basis of small classes, one instructor chosen from among the departments of economics, philosophy, government and history being in charge of a section of approximately thirty students throughout the year. The course, therefore, is not made up of a series of lectures given by specialists in various fields. Great care is exercised in selecting the staff and only those of outstanding personality and teaching ability, who have been willing to sacrifice the normal academic ambitions to specialize in their particular fields and to do a great deal of painstaking and diligent study in order to acquaint themselves with such a diversified field, have been invited to coöperate in the course. Classroom work is devoted almost exclusively to discussion based upon the syllabi and required reading assignments. Hourly quizzes and final examinations are the same for all sections. The matter of required notebooks is left to the discretion of each instructor. In connection with the second year of the work every student is required to take at least six field trips; this field work is idesigned to give the student firsthand contact with the various nstruments of our industrial civilization: factories, stores, markets

and governmental institutions. In order to give these first-hand contacts their full meaning an explanatory and descriptive booklet has been prepared entitled "Contemporary Civilization B Field Work Manual."

It is our candid opinion that such a course as the Contemporary Civilization course just described is the type of survey or orientation course which would give the engineering student of any school an insight into his civilization that, with few exceptions, he does not now get from his course of study. This course is only a sample of what might be done. It should not be followed slavishly. Rather, any institution which believes this type of course to be worth while should work it out to meet its own particular needs. Personnel is very important! With us the course has been very successful, largely because it was made to fit our own institution, the small size of the sections, the continuity of instruction, the feeling on the part of those who have taught it that it was worth doing and worth doing well, and, above all, because Columbia College and the professional schools related to it are institutions which insist upon the rounded education of youth.

Discussion

By DEAN H. DIEDERICHS

Cornell University

In his discussion of this subject, Dean Diederichs stated that he had recently outlined as a frame work for the development of an engineering curriculum the following divisions:

1. The Fundamental Sciences.
2. Professional Studies.
3. Social Sciences.
4. Professional Electives.
5. Free Electives.

Acknowledging the need of division (3), Dean Diederichs agreed that the engineering graduate of the present day is seriously lacking in a knowledge of those social aspects with which his work is intimately connected. "The only question relates to what the work in this division should be, how much time should be devoted to it, and last but not least, how the work can be fitted into a standard four year curriculum."

The inclusion of English and History or of Economics and Industrial Organization only partially solves the problem. When an attempt is made to widen the scope of this type of work, great

difficulties are encountered because of the necessary curtailment in the time allotted to long established technical courses.

Dean Diederichs further states, "I conceive that the work offered should cover as to content the history of civilization, going back far enough to show how various philosophies and trends have in the past combined to produce our present-day social economy, followed by a thorough discussion of present-day economic, social and political problems, both national and international."

The several methods by which this work could be organized include, first, sending the engineering student to the College of Arts and Sciences for individual courses in history, economics, etc. Second, to offer the student a survey course which shall give a cross section of all the special fields of the social sciences, properly correlated with engineering. The former method does not provide the integrated program that can be presented by the latter method which, as at Columbia, offers an excellent solution provided the staff is adequate.

Colleges with four year courses may not have the necessary staff or time, but since the need is imperative there may be a third method of offering the work. Suggesting that instruction in the social sciences might better be offered to the maturer students of the Sophomore year, Dean Diederichs states that Economics and Industrial Organization might be offered in the second year, followed in the Junior year by a course in the historical development of our present day civilization (similar to the Columbia course). This would lay a foundation for the senior work which might be given as a series of special lectures on contemporary social and political problems (such as those covered in the second year of the Columbia course). These lectures could be offered by outstanding authorities and might be paralleled by seminar discussions on the lecture topics. The success of this method would depend upon the seminar leaders and the overcoming of the difficulty of arranging for the authoritative lecturers. Dean Diederichs concludes with his belief that "in any case for any college which is hampered by both lack of adequate staff and by time, the method outlined may offer the solution of a problem, which is indeed very urgent in our engineering educational program."

By WILLIAM O. HOTCHKISS

President Rensselaer Polytechnic Institute

Dr. Hotchkiss first expressed the opinion that an excellent piece of work has been done in the preparation and the giving of the Columbia course. He approved its purpose and agreed as to its value.

Noting some of the statements in the paper under discussion, such as "an individual is, after all, not well educated unless he or she has at least some conception of the broad field of intellectual endeavor," Dr. Hotchkiss warns that "the inference might be drawn from these statements that they apply particularly to engineering students and engineering curricula, but I wish to call attention to the fact that such is not the case. They are general statements which apply to any college course."

Dr. Hotchkiss defends the teacher of engineering as having tried to foresee all the things his students may be called upon to do, so as to prepare them faithfully. "Within this century, most of our engineering curricula have increased by about one-third the number of hours required of our students. Yet, here comes a demand from the economists and historians, yes, even from the President of the United States—that we give more time to teaching our students their responsibility for the social and economic set-up."

In answering the charge that courses in engineering are guilty of "narrow specialization" Dr. Hotchkiss retorts, "Why pick on the engineer?" "Why shouldn't the economists be compelled to get out of their narrow rut, broaden their conceptions, and set right their erroneous notions by studying engineering? Why should the student of history and political affairs not be given a 'liberalizing' course in engineering? Why should law students be permitted to go on with such a narrow specialized course as now given them? Why should not their future leadership be given the fuller, richer understanding of our industrial and social conditions that would, beyond question, be theirs if they were compelled to spend two added years in the engineering college?"

Dr. Hotchkiss indicated that many engineering graduates acquired their understanding in economics, history, and sociology since graduation. Following the general attitude of engineering alumni on technical subjects, many alumni urge that special courses be included in the engineering curriculum. The inclusion of desirable courses in the four year curriculum must be decided on a basis of careful analysis of the curricula by the whole of an engineering faculty.

Dr. Hotchkiss is by no means sure that approximately ten per cent of the four year curriculum should be devoted to a course (such as Contemporary Civilization). "As engineering schools, we are engaged primarily in turning out capable engineers. As such, our first responsibility to society and to our students is served only if we insist on adequate preparation in engineering. It does not help society or our graduate, materially, if he has an abundance of 'liberalizing' training, and the building he constructs falls down." He believes that an equitable amount of time must be allowed for

the various divisions of study and in order of importance they are stated in terms of the following objectives:

1. Adequate grounding in the fundamentals of engineering. If the time available permits, next in importance should come—
2. Adequate training and practice in the use of the English language. If, after this, time will permit further additions to the curriculum there should be added—
3. Adequate "liberalizing" courses that will make the student a more intelligent citizen, and a better leader of men.

"It might be said with much truth that I have reversed the real order of importance—that a man should be first an intelligent citizen, and after that an engineer. From a general point of view, that is true. From the point of view of the engineering college, it is not true. There are many agencies by which men acquire education. The newspapers and magazines and books are at least as important educational institutions as the colleges. The engineering college is a specialized agency for a particular purpose. It cannot, even if it wanted to, assume the whole responsibility, as though it were the sole agency through which its graduates were to receive all their education. It must leave much of desirable, yes, even necessary education for the good citizen, to be acquired from the other agencies that precede, parallel, and follow an engineering course.

"The faculty of Rensselaer Polytechnic Institute, after much consideration, recently adopted a statement of the objectives of the Institute. One statement in the list, it seems to me, is most completely expressive. I wish I might claim its authorship, but since I cannot, I give due honor to the committee who wrote it. That objective is 'Stimulation, not saturation of the intellectual faculties.'

"It has long been my opinion that we waste a lot of time in all our college curricula, not only in engineering, but in other branches, because of a tacit assumption that college is the only place where a man can get an education, and that if a given subject is not included in the curriculum, all hope of ever being informed on that subject is lost. I feel that we should frankly admit to ourselves that there are many ways in which needed education can be obtained; that as college teachers, we should adjust our aims to the most essential objectives; and that we should leave to other agencies their proper share of the responsibility. For the fields of urgently desirable knowledge that we cannot encompass adequately in our curricula, we should endeavor to provide an introduction that will be as full of stimulation of interest as our abilities will permit. While we may not be able to 'saturate' we should endeavor most energetically to 'stimulate.'"

Dr. Hotchkiss summarizes his conclusions on the course under discussion in the following points:

1. It is too long to be permitted in a four-year engineering course. We cannot justly take ten per cent of our students' time for this subject.
2. There are fields of knowledge other than this that are of importance to the engineer.
3. One very desirable way of imparting much of the information included in such a course will be to have the economic viewpoint pointed out competently in all the engineering classes.
4. Such a course would have better effect if given to upperclass men.
5. Every engineering college faculty should carefully study the course outlined in the paper under discussion and evaluate it in comparison with all other courses now offered in the curriculum. Some course along these lines, properly modified in length to fit proportionately the time which our engineering students have available, should be included in the curriculum.

By H. S. ROGERS

President Polytechnic Institute of Brooklyn

In discussing the subject of this paper Dr. Rogers stated that the planning or appraisal of the engineering curriculum was limited by the time restrictions of the four years of undergraduate study. Of these four years, approximately two are devoted to engineering science and technology, another to the fundamentals of physical science, mathematics and graphics, and the fourth to the humanities and social sciences. Dr. Rogers expressed satisfaction with this proportioning and stated that it compared favorably with the balance and distribution of time in the curriculum of a student in Liberal Arts with scholarly intent.

Dr. Rogers noted that the breadth and preparedness of the engineer's thought had recently been challenged, and questions "whether this challenge can be met by an adjustment of four year curricula, whether curricula must be extended, or whether engineers must look forward to post-graduate or post-collegiate study of a nature to supplement their technical training." Noting the increasing amount of advanced study undertaken by engineering graduates he avers that "it is certain that those who aspire to any large responsibility of an executive nature and even those who aspire to informed citizenship must recognize the impossibility of preparing

adequately for these through the pursuit of a curriculum which is designed primarily to prepare men for technological duties."

An analysis of the single undergraduate year devoted to humanities and social sciences shows that over one-third of this time is devoted to English composition and speech. There are three forms of development of the remaining two-thirds of a year's time, in which engineering students may find some approach to the vast economic, social and political problems which will surround them in practice.

First, "a sequence of courses similar to that in contemporary civilization and contemporary problems, which we have just heard described that cuts across departmental lines and focuses attention upon the broad and encompassing human problems of the day, certainly has the most distinctive merits of reality, timeliness, continuity, and perspective, all aiding in the building of a background from which public questions may be approached with understanding and decisions reached with wisdom. It seems obvious that the conditions and the devoted personnel essential to such a work are available only in a university."

Second, the available time "might be thrown open to general electives through which students could pursue particular intellectual, critical, or aesthetic interests. Here again any degree of richness would require departmental resources beyond those of most technical institutions."

The third alternative is that generally followed "in which courses in government, history, economics, psychology, and sociology of a fundamental and traditional nature are prescribed or made elective in part to all engineering students. These courses are generally identical with the introductory courses for students who expect to specialize in some field of social science and are, therefore, too abstract and too limited in scope for those who cannot pursue subsequent courses to certain levels of mastery."

Adding to these procedures Dr. Rogers notes a fourth in which he would prescribe studies in the fields of government, economics and psychology. Indicating certain details of the courses in these subjects Dr. Rogers states the belief that such a group of courses would prove more feasible for some institutions and none the less significant than the course in contemporary civilization. He also is confident of finding a staff for such courses in a technical school and feels that a considerable benefit comes to the staff in the development of such course work.

As a conclusion Dr. Rogers states, "In contrasting the two it seems to me that the courses in government, economics, and psychology would form a background of knowledge to which the engineer could relate his individual experiences not alone in public affairs

but in industrial and administrative affairs and find there, significant relationships to procedures of an established and orderly nature and a basis for his personal judgments. The sequence of courses in contemporary civilization, on the other hand, is directed quite definitely toward an understanding of economic political conditions which would be more significant in preparing a man for his responsibility of citizenship."

TEACHING APPLIED COURSES *

By FRANK KEREKES

Professor of Structural Engineering, Iowa State College

"Engineering is the science and art of directing the *applications* of the science of mechanics in the economic utilization of the forces and materials of nature."—*Anson Marston.*

I Basic Considerations.
- *A.* Analysis of objectives.
- *B.* Application of educational principles.
- *C.* Appraisal of teaching effectiveness.

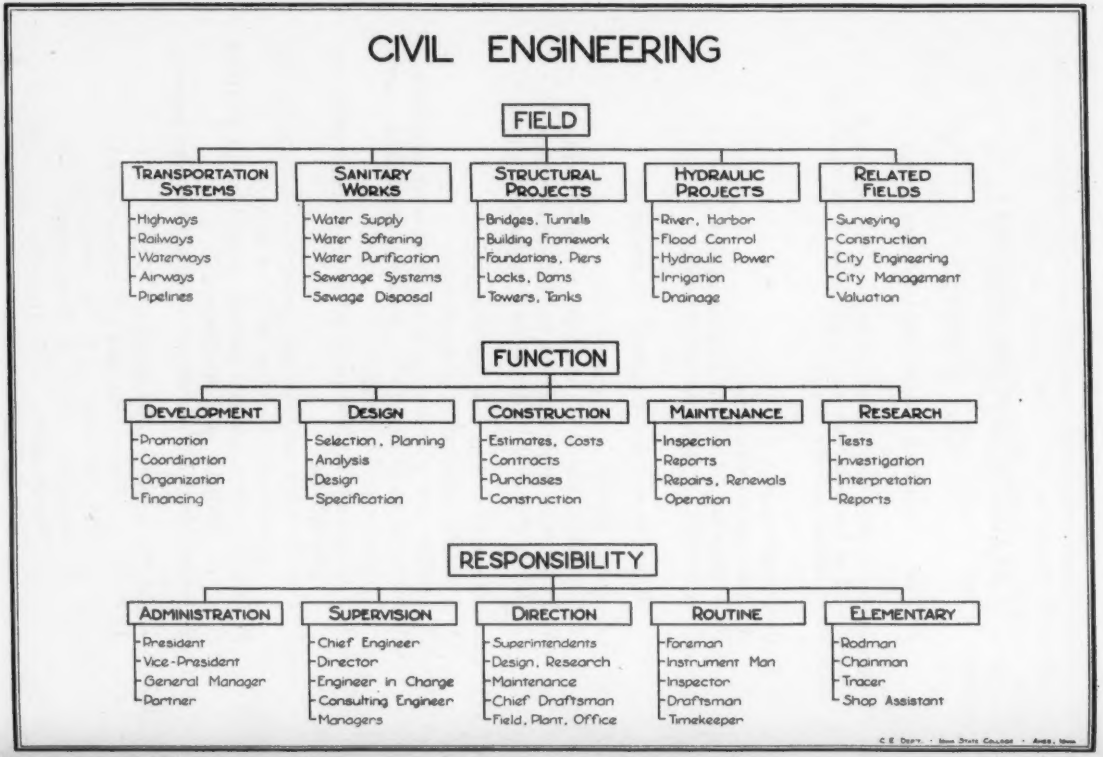
ELEMENTS OF ENGINEERING PROFICIENCY

II. Professional objectives in engineering.
- *A.* Technical, scientific, and economic knowledge.
- *B.* Functional proficiency in technical procedure.
- *C.* Organizing skill in directing thought and action.

III. Characteristics of Engineering Thought.
- *A.* Practical application of knowledge.
- *B.* Logical and quantitative consideration of problems.
- *C.* Investigational attitude toward established facts, truths, and principles.
- *D.* Adjustment of precision to practical and economic considerations.
- *E.* Provision for expected but indefinite contingencies by the introduction of a factor of safety.
- *F.* Careful, thorough and orderly procedure in arriving at solutions and conclusions.
- *G.* Independent verification of results whenever possible.

IV. Essential Personality Qualifications.
- *A.* Personal effectiveness and self-improvement.
  1. Self-confidence.
  2. Initiative.
  3. Thoroughness.
  4. Industry.
  5. Dependability.
  6. Enthusiasm.
  7. Integrity.

* Presented at Civil Engineering Division Conference, Madison Meeting, S. P. E. E., June 1936.


CIVIL ENGINEERING
FIELD
TRANSPORTATION SYSTEMS
Highways
Railways
Waterways
Airways
Pipelines
SANITARY WORKS
Water Supply
Water Softening
Water Purification
Sewerage Systems
Sewage Disposal
STRUCTURAL PROJECTS
Bridges, Tunnels
Building Framework
Foundations, Piers
Locks, Dams
Towers, Tanks
HYDRAULIC PROJECTS
River, Harbor
Flood Control
Hydraulic Power
Irrigation
Drainage
RELATED FIELDS
Surveying
Construction
City Engineering
City Management
Valuation
FUNCTION
DEVELOPMENT
Promotion
Coordination
Organization
Financing
DESIGN
Selection, Planning
Analysis
Design
Specification
CONSTRUCTION
Estimates, Costs
Contracts
Purchases
Construction
MAINTENANCE
Inspection
Reports
Repairs, Renewals
Operation
RESEARCH
Tests
Investigation
Interpretation
Reports
RESPONSIBILITY
ADMINISTRATION
President
Vice-President
General Manager
Partner
SUPERVISION
Chief Engineer
Director
Engineer in Charge
Consulting Engineer
Managers
DIRECTION
Superintendents
Design, Research
Maintenance
Chief Draftsman
Field, Plant, Office
ROUTINE
Foreman
Instrument Man
Inspector
Draftsman
Timekeeper
ELEMENTARY
Rodman
Chainman
Tracer
Shop Assistant
C.E. Dept. · Iowa State College · Ames, Iowa

B. Social effectiveness in coöperation with and direction of associates.

1. Appearance.
2. Physical vigor.
3. Social qualities.
4. Tact.
5. Tolerance.
6. Cheerfulness.
7. Spirit of service.
8. Emotional control.

ELEMENTS OF TEACHING APPLIED COURSES

V. General Considerations of the Thinking Process.

A. Thinking is stimulated by curiosity of an objective nature.

B. Sequence in the process of thinking is guided by suggestions that arise from associating the conditions of a problem to the fund of existing knowledge.

C. The common mental activities may be resolved into the four component parts of investigation, assimilation, classification and explanation.

D. Expression by speech, writing, graphics, and mathematics is the evidence of the process and quality of thinking.

VI. Functional Objectives in Teaching Applied Courses.

A. Facility in technical procedure or manipulation.

B. Establishment of a minimum reservoir of essential knowledge—facts, truths, principles.

C. Exercise of judgment in choice between alternates, selecting pertinent evidence, methods of procedure.

D. Arriving at conclusions by correct processes of reasoning.

E. Development of creative skill in the synthesis of technical procedure, knowledge, judgment and reasoning for the purpose of arriving at new ways of doing things.

VII. Specific Techniques for Realizing the Functional Objectives in the Teaching of Applied Courses.

A. Good thinking may be developed when its value is appreciated by the student, when sufficient opportunity is provided for its practice, and when superior thinking is well rewarded.

B. Selection of knowledge—facts, truths, principles on the basis of interest, understanding and frequency of use.

C. Use those problems that are true to life and call for essential knowledge and the exercise of reasoning, judgment and creative skill.

D. Let each new problem grow out of interesting previous problems; its relation to the acquirement of professional objectives and functional thought objectives should be evident; encourage students to find their own references and to employ their own process of solution; assist primarily by graded thought questions.

E. Plan for class discussion by applying the principles for controlling interest and stimulating thought.

F. Conduct class discussion according to the plan concentrating on a discussion of the problem that was solved and on the introduction of the new problem.

VIII. Measurement and Verification of Results.

A. Avoid tests that require the repetition of memorized processes, facts, truths or principles.

B. Formulate tests that measure the students' power of constructive thought as a means of arriving at his mastery of the professional objectives in engineering.

C. Maintain a chart of personality qualifications and the students' names and indicate the students' degree of proficiency at certain intervals, say at beginning, the middle and end of each semester or quarter.

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CONFERENCE ON PLACE OF MANAGEMENT COURSES IN THE ENGINEERING CURRICULA

PLACE OF MANAGEMENT IN ENGINEERING CURRICULA

By C. E. BULLINGER,

Professor and Head, Department of Industrial Engineering,
The Pennsylvania State College

The committee of the S. P. E. E. on the Place of Management in Engineering Curricula has asked me to speak on the "Four Year Industrial Engineering Curriculum" side of the question, "Special Management or Industrial Engineering Curricula vs. Management or Industrial Engineering Courses in Mechanical and Other Engineering Curricula."

I wrote President Prentice that it would be impossible for me to debate such a question because of the viewpoints which we of the Department of Industrial Engineering at Penn State hold. The position which we take is as follows:

1. We are definitely of the opinion that there should be included in the list of fundamental courses for training in engineering a course which might well be called, "Introduction to Engineering Management." You may recall that the report of the investigation of engineering education recommended that certain courses were fundamental to training in engineering. Nothing was said about management except a course called "Introduction to the Economics of Engineering."

   The practice of the Department of Industrial Engineering at Penn State has been for a long time to offer such an introductory sequence of courses to other curricula in engineering. A sequence of two courses having a combined value of four credits is designed for the construction field. Another sequence of three courses having a value of eight credits is designed for the manufacturing field. They are at present elective courses rather than required courses. We believe that they should be required courses since they are fundamental to training in engineering.
2. We also believe that the field of Industrial Engineering is of such importance that it should merit a separate curriculum. We also believe that it should be considered as a

differentiation rather than a specialization within a curriculum.

It is plain, therefore, from what has been said before that the question which will have to be discussed, from my standpoint, is whether or not a curriculum in industrial engineering is justifiable.

On what basis is a new curriculum justified?

When a new curriculum is proposed at The Pennsylvania State College, the Senate Committee on Courses of Study requires it to be justified in terms of the following policy:

1. To satisfy the legitimate demands of outside agencies.
2. When no other existing curricula will adequately satisfy the need.

Did the other major curricula in engineering come into being in such a way that those questions could be easily answered and their curricula justified? The history of engineering and engineering education may give us the answer.

President Williams in his book, "Building an Engineering Career," describes their growth in this manner:

> With the growth of public works, the improvement of iron and other building materials, and the development of the art of planning such works, men engaged in designing and building public works other than military called themselves civil or civilian engineers as distinguished from military engineers.
>
> The Institution of Civil Engineers was founded in 1818 and the American Society of Civil Engineers in 1852.
>
> With the development of the steam engine and other machinery, mechanical engineering for those primarily interested therein became separated as a distinct profession, leaving in the original stem of civil engineering those projects of a stationary or static character. The Institution of Mechanical Engineers in England was founded in 1847 and The American Society of Mechanical Engineers in 1880.
>
> At about the same time, mining engineering branched off to include the operations involved in extracting useful minerals, testing and valuing the ores, designing the required works both above and underground. The Institution of Mining Engineers was founded about the middle of the century and The American Institute of Mining Engineers in 1871.
>
> In a similar manner when electrical machines and other devices began to have a wide application, electrical engineering branched as a separate profession. The Institution of Electrical Engineers was founded in 1883 and the American Institute of Electrical Engineers in 1884.
>
> With the growth of chemical manufactures and chemical control of mechanical manufactures, still another branching has occurred known as chemical engineering.
>
> The American Institute of Chemical Engineering was founded in 1908.

Thus it is seen that military engineering was the root from

which the other branches grew. These branches of civil, mechanical, mining, electrical and chemical engineering have grown so that they are too great for the original stem to hold them and have become major fields.

Another interesting fact is that the definition of engineering has changed with the growth and development of the art and science of engineering and industry.

Tredgold defined engineering as, "The art of directing the great resources of power in nature for the use and convenience of man. In the Report of the Investigation of Engineering Education, these words are found:

> For the sanction of a definition, we may turn to the walls of the library of the United Engineering Societies, where we find inscribed in letters of gold the words "Engineering—the art of organizing and directing men and of controlling the forces and materials of nature for the benefit of the human race," a happy blend of the fundamentalism of Tredgold and the modernism of Stott. Usage gives to sweeping definitions of this type a more restricted sense. Engineering tradition makes the control of the forces and materials of nature the central and primary factor and subordinates to this purpose the organization and direction of men. Our definition implies that engineering has three distinctive qualities. The first is a scientific technique for the control of the forces, materials and energy of nature; the second is a technique for the organization of human effort; and the third is a technique for appraising the resulting benefits to mankind.

A study of the information concerning the history of engineering shows the following:

1. That the scope of engineering has widened and broadened as the art and science has developed and as industry has grown.
2. That new curricula in engineering have been initiated for the following reasons:
   - *a.* The discovery of new materials and their development.
   - *b.* The practical application of natural forces.
   - *c.* The development of specific processes arising out of the application of natural forces.
   - *d.* The organization of industrial life in accordance with specific kinds of engineering structures and machines.
3. That engineering societies have been organized to promote the art and science of their particular field.
4. That the initiation of curricula follow the industrial application but precede the formation of a society.

How do these findings apply to industrial engineering?

Does it satisfy the legitimate demands of outside agencies?

Are there no other existing curricula which will adequately satisfy the need?

The following may be used as a definition of industrial engineering:

Industrial engineering brings together men, materials, money, machines, and management to solve the problems met in the conversion, transformation and fabrication of raw materials into the products of industry.

Thus, it definitely possesses the second quality mentioned in the definition of engineering; namely, "a technique for the organization of human effort." Whether it can qualify also for the third quality, namely, "a technique for appraising the resulting benefits to mankind," remains to be seen.

It came into being partly because of the studies made by Frederick W. Taylor, his associates and others into the problems of doing work. Drury in his study of Scientific Management de scribes these early studies as having occurred in three stages:

1. The determination of what constitutes a day's work for man, and how can he be induced to work at that rate.
2. The standardization of all the facilitating tools, equipment and services.
3. The building of an organization willing to take responsibility.

Taylor expressed the fundamentals of his work by saying:

1. The development of a science for each element of a man's work, to replace the old-rule-of-thumb method.
2. The selection of the best worker for each particular task, and then the effort to train, teach, and develop the worker, in place of the former practice of allowing the worker to select his own task and train himself as best he could.
3. The bringing of the science to the worker, and coöperation with him, to the end that all work might be done in accordance with the principles of the science which has been developed.
4. The assumption by management of the responsibility for the foregoing, and for planning the work.

Like the examples given of the development of the other branches of engineering, industrial engineering was born and developed in an already established branch of engineering, namely, mechanical engineering. At least, most of the men associated with Taylor were members of that society, and the most important papers on the subject were presented at the meetings of that society.

The rapid development of the United States into the greatest industrial nation provided the soil in which this newest branch of engineering could grow. The increasing complexity of the problem of manufacturing has made it necessary that a group of engi-

neers be provided who understood the problem of coördinating the various elements of not only a production program but also of a construction program as well as an operating program.

Thus a technique which at first was confined to the production of commodities has become extended and amplified so that it applies with equal force to the management of all kinds of enterprises and in the field of distribution as well as in the field of production.

A quotation from C. W. Lytle in the JOURNAL OF ENGINEERING EDUCATION for June 1932 is as follows: "The earliest single course in shop management, so far as we can ascertain, was offered in 1902 at the University of Kansas and was taught by Hugo Diemer. Colonel Diemer had previously written articles on the subject for Charles B. Going's *Engineering Magazine* and through these articles became acquainted with Taylor. In 1907 General Beaver, Ex-Governor of Pennsylvania and President of the Board of Trustees of The Pennsylvania State College, had a conversation with Taylor at the Union League Club of Philadelphia. Beaver told Taylor that he was looking for a man to head their M.E. Department, who could 'teach M.E. from the standpoint of manufacturing rather than from the standpoint of power plant tests and higher mathematics.' Taylor recommended Diemer and in this way Diemer became, in 1908, the head of the first Industrial Engineering Department in the United States."

It is interesting to note that the teaching of this technique began shortly after the studies were begun and at a time when the manufacturing industries of the nation were fast developing. It is also interesting to note that the curriculum was established even before the celebrated railroad rate case, at which time scientific management became popularized throughout the nation.

As in the cases of the other branches of engineering, so in this case, the organization of a society set apart to foster the study and development of this technique followed soon after.

Drury says: "The Taylor Society was formally organized December 4, 1911, as the Society to Promote the Science of Management. After the death of Taylor the name of the society was changed to the Taylor Society: A Society to Promote the Science of Management.

"A more recent effort to mobilize the efficiency movement was the formation, May 26, 1917, of the Society of Industrial Engineers."

Just recently these two societies have merged into The Society for the Advancement of Management. The American Management Association is another very strong society that has for its purpose the furtherance and development of the art of management.

Is there potential demand for graduates in industrial engineering?

In Report No. 25 of the National Industrial Conference Board on "Engineering Education and American Industry," August 1923, may be found the following:

1. There is a rapidly growing need for administrative and technical ability in practically all lines of activity. This is especially true of the manufacturing and mechanical industries.

2. There is an increasing demand for graduates of engineering schools to enter upon the work which will fit them for positions of administrative as well as technical responsibility.

3. The demand for young men with capacity for becoming administrative or technical leaders is already far greater than the number of such men now being graduated from the engineering schools.

The growing importance of trained leadership in industry is evident not only from the new developments in the organization and processes of industrial production and distribution during recent years, but in the present position of American industry in relation to world conditions. The history of American industry during the past decades reveals a picture of transition and growth unparalleled in rapidity and extent. The marked shifting of the population from agricultural to industrial pursuits has tested our powers of organization and assimilation. The expansion of industry has been accompanied by vastly increased complexity of industrial operations, and the grouping of greater numbers of workers in corporate units has placed upon employers an increased social responsibility toward employees and towards the life and affairs of the community. All of these changes have created problems of human, social and political relationships in which industry and society as a whole have become increasingly dependent upon trained technical and administrative leaders.

This report shows that the percentage of those gainfully employed who were administrators, supervisors and technical experts had increased from 1.25 per cent in 1870 to 3.6 per cent in 1920 and was expected to further increase to 3.8 per cent by 1930.

To quote again from the report:

The reasons for this growth in the demand for experts and leaders lie in the change of methods by which industrial work is performed. They consist mostly in the development of corporations, in the increasing use of machinery, power and other labor-saving devices and in the elaboration of methods of control in production and distribution. Methods of mass production greatly increase the amount of product per worker, but require a relative increase in the proportion of planners and administrators.

These facts and figures demonstrate that both the normal progress in industrial methods and the approaching new competitive conditions will require a more rapid increase than ever before in the quality and number of trained experts and leaders.

At present the demand for administrative talent is more pressing than for technical experts, but in the conditions of international competition now developing, research will be of the utmost importance. Success will lie in the improvement of technical processes, utilization of by-products and reduction of waste as well as in better methods of production and distribution. The supervisory and administrative leaders in our industrial structure exceed the technical experts numerically at least four to one, but no one should lose sight of the fact that both groups are essential and that in each there are positions of highest responsibility and honor.

Throughout this period of development, the field of activity for engineering graduates has expanded continually. Not only have the lines of national activity broadened, but the proven capacity of engineering graduates has led industry to place them to an increasing degree in positions of leadership in many departments, thus shifting them more or less from the lines for which they were specifically prepared.

A resume of the above findings from history indicate the following:

1. The definition of engineering had changed to include the human element.
2. Problems of the coördination of human effort arose with the development of industry.
3. The study of these problems resulted in a body of principles of management.
4. The ratio of supervisors and administrators to total number of persons gainfully employed is increasing.
5. That the ratio of supervisors and administrative leaders to technical experts is as four to one.

It is, therefore, apparent that there is a legitimate demand from industry for persons trained in the field of management, and industrial engineering.

The second question asks that a new curriculum be justified when no other curricula will adequately satisfy the need.

Referring to the quotation previously given concerning the establishment of courses in management and the curriculum in Industrial Engineering at Penn State, it is very evident that had there been a curriculum in existence at that time, which would have been satisfactory, the new one would not have been necessary.

Are the present major curricula satisfactory for this purpose? Apparently the original curriculum in civil engineering was not satisfactory enough for the training of mechanical engineers, and it in turn was not satisfactory for training electrical engineers. So, to-day, one may say with some justification that none of the major curricula are satisfactory for training in the field of management. It has often been suggested that engineers trained in

the major fields of engineering have grown into administrative positions and work. Since it is done in other major branches of engineering, would it not be more logical to train rather than shift the man to the new field?

Another question may be raised at this point. Is this new curriculum a differentiation or a specialization?

Differentiation is defined as "to acquire a distinct and separate character." Specialization is defined as "an occupation or study limited to one particular line."

Industrial engineering is a differentiation because it has a character as distinct and separate from the other major branches of engineering as they have from each other. Its distinctiveness consists in that it deals with the coördination of human effort with technical forces and apparatus.

It is not a specialization because it does not limit itself to one particular line. If a curriculum should be proposed for the study of Motion and Time Study or Personnel Management, that would be a specialty in the field of Industrial Engineering in the same way that radio is in electrical engineering and air conditioning is in mechanical engineering.

Dr. Wm. Learned in study No. 14 for the Carnegie Foundation for the Advancement of Teaching says, "the great advantage of differentiation is that it permits the construction of a thoroughly integrated curriculum, which in turn serves to concentrate all of the work of the student upon a unified problem. Whenever such concentration is possible it is obviously the method of educational organization that will yield the largest return."

Is a curriculum in industrial engineering capable of being thus integrated?

At best the aim of any curriculum should be, in simplest terms:

1. To develop the ability to think effectively.
2. To develop the ability to express one's self effectively.
3. To train the student in a definite technique.

In addition to the above objectives, this curriculum must have management as one of its objectives and must be an engineering curriculum for its other objective.

Does the curriculum do this?

The basis of this curriculum is that list of subjects which the investigation of engineering education listed as fundamental to training in engineering plus an introduction to engineering management. Since engineering management is the principal objective of this curriculum, concentration is made upon this particular subject.

You will note that the same procedure is followed by the other branches of engineering.

Since it is based on the first two years of science, mathematics, English and drawing, it should develop the ability to think effectively. For the same reasons, it should develop the ability to express one's self in the many ways that an engineer uses, namely, mathematical, graphical, written and spoken words.

The technique that it trains for is that of management. This technique may be considered to consist of three sequences of courses coördinated by a fourth sequence of courses.

1. Methods sequence.
   A sequence of courses dealing with the methods of manufacturing, including the engineering of tools, the design of jigs and fixtures, motion and time study, and factory planning and layout.
2. Cost control sequence.
   A sequence of courses dealing with the financial control of an enterprise, including work in accounting, cost accounting, budgetary control and standard costs.
3. Personnel sequence.
   A sequence of courses dealing with the mechanics of hiring, training, safety, industrial health, etc., psychology, as well as the problems of the executive in his individual relations with his employees.
4. Organization sequence.
   A sequence of courses dealing with the history of scientific management and the technique of the coördination of methods, cost control and personnel.

In addition to courses which are fundamental to engineering training and to courses making up the management technique, there are several additional courses. They are kinematics, machine design and steam power plants. It is obvious that these subjects are in the nature of mechanical engineering. And so they should be, since historically it was from mechanical engineering that industrial engineering developed.

Perhaps the time is ripe for another change to take place. Our definition of industrial engineering did not specify any particular kind of material or type of process which were to be brought together. Why limit the term industrial engineering to include only mechanical engineering work? Permit the student to substitute for the series of courses which are mechanical in nature, those pertaining to other branches of engineering. The curriculum would

still be industrial engineering but with emphasis on certain classes of materials or processes.

Each of the above variations has to do with the management of the internal aspects of an industrial enterprise. Some students are interested in the management of the external aspects of industry. What would be more logical than to permit them to substitute for the junior-senior engineering sequence, one consisting of subject matter dealing with commerce and applied economics.

The new combination would then have a two-year base of pre-engineering courses, a stem of management technique which is applicable either to internal or external problems of management, and an accompanying junior-senior sequence in commerce. Since the fundamentals of engineering training will not be accomplished by this program, an appropriate degree would be Bachelor of Science in Industrial Management.

Industrial engineering would then apply to the problems of internal management while Industrial Management would apply to the problems of external management.

The curriculum is therefore an integrated curriculum because it is definitely planned to accomplish an end. The end is the study of the problems involved in the coördination of the various factors in the management of industry. By making use of the suggested substitutions, it is made flexible enough to meet the demands of industry.

In conclusion it has been shown that the curriculum of industrial engineering and its variations are justified because:

1. It fills a need demanded by outside agencies.
2. There is no other existing curriculum that will do the work or fill the need.
3. It meets the modern definition of engineering.
4. That it came into being in the same manner as the other major branches of engineering.
5. That technical societies have been formed to help its development.
6. That it is a differentiation and not a specialization.
7. That it is an integrated curriculum.
8. That it meets a student demand.

PLACE OF INDUSTRIAL ENGINEERING AND MANAGEMENT COURSES IN ENGINEERING EDUCATION

By JOHN R. DuPRIEST

University of Minnesota

I have been asked to discuss the place of Industrial Engineering and Management courses in engineering education. During the past few years there have been a number of papers published in the JOURNAL under such headings as Commercial Engineering, Industrial Engineering, Industrial Management, Engineering Administration, Industrial Organization, etc. The writers in most cases have dealt with different phases of the same general subject, the operation and management of industrial enterprizes. New courses are being developed and new curricula are being proposed annually, all in an effort to meet a changing situation.

The majority of engineers find an outlet for their services through some type of industry and it might be worth while to ask what changes have taken place in industry which affect the education of the engineer and what caused the changes.

Many industries have changed from the handicraft stage to the machine age during the lifetime of most of us in this room, and also many of the ordinary routine duties of home life have been completely changed by the use of machinery. We wash the clothes, milk the cows, sweep the floors, iron the shirts, wash the dishes, heat our homes, and purify the air with machinery.

From whence does all this machinery come? The answer is from the brain of the engineer. The engineer has changed our living conditions, working conditions, transportation system, manufacturing system, communication system, entertainment, social and economic life, and has precipitated problems which our politicians seem unable to deal with effectively. In bringing about these changes the engineer, whether he wanted to do so or not, has greatly extended his field of activity and at the same time he has increased his self-imposed responsibilities manifold.

Engineers during the past few years have developed many new technics for dealing with their special problems by applying scientific methods of analysis and measurement to problems in production, distribution and management, and these new technics are finding their way into our educational systems. It should be helpful, therefore, if we analyze industrial operation and management and find out what the changes have been in recent years, which seem to require engineers with special training in new fields.

The operation of a large industrial plant may be considered under the following major divisions:

1. Design and development.
2. Manufacturing.
3. Marketing of product.
4. Management.

Each of these major divisions might be divided into a number of subdivisions depending on the size of the industry and the kinds of products manufactured.

The first of these four divisions has long been considered the engineer's job. When tools and machinery began to replace hand labor, the manufacture of goods became more complex, and with further development of interchangeable parts for quantity production, the manufacture of goods became highly technical. The engineer, therefore, has been called upon to assume the responsibility for the use of his newly developed tools and machinery, thus acquiring control over manufacturing operations or the second major division.

Dean Kimball in the preface of the first edition of his "Principles of Industrial Organization" published in 1913 (23 years ago) said, "Just as tools and processes of our forefathers became inadequate as enterprises grew in magnitude so the simple administrative methods formerly in use have long since been outgrown by modern plants." As a result of this situation, management methods had to be improved to keep pace with production methods, and it was a logical thing for the engineers who had created the new problems in industry to set themselves to the task of improving management methods. You are all familiar with the results that have been achieved in the field of management, both technical and general management, since engineering methods have been applied to such problems.

With the engineer now having responsibility for design, development and production and leading in the application of scientific methods to management problems, he has become an important factor in the purchase of materials, tools, and machinery. This situation has created a large and very critical group of buyers with the result that salesmen of industrial equipment to be successful must also be technical men who know their product well, can answer technical questions, and in many cases serve as field engineers for service work.

It is thus evident that the engineer is now functioning in all of the four major divisions of industry mentioned above. His responsibilities have increased manifold and he must deal with technical problems, human problems, and economic problems. If the engineer's responsibilities and duties have changed, why should not his education change?

Many schools have recognized the changing situation and are making a real effort to meet the problem. New courses are being offered dealing with manufacturing methods, plant layout, cost systems, time and motion study, and management problems. This is in the right direction and the results obtained have been worth while. Such application of engineering methods to industry are now essential if a company expects to survive.

A problem which confronts educators today is how to find a place in the program for these new courses. Some educators have been very slow to appreciate the value of, or to recognize the demand for, instruction in these new fields, and therefore have not taken the matter very seriously.

There is another group of educators who think that engineers who are engaged in manufacturing or management work are a new breed of engineers, and therefore should receive a special kind of training and professional degree. I like to think of this new application of science to industrial problems as a broadening of the field for the engineer rather than another highly specialized job. We have had a number of such cases in the engineering profession during the past twenty-five years, and there will no doubt be more in the future.

The fields of reinforced concrete construction for buildings and highways, sanitation work, telephone, radio, and automobile work are large and important units in our industrial system, and have presented many new problems to be solved. I do not believe, however, that separate curricula or degrees are being advocated to any extent in these fields, yet many new courses have been developed to meet the needs of students interested in such work. I think the continual broadening of the engineer's activity is really an argument for less specialization and broader fundamental instruction in the undergraduate course.

It should be noted that as new fields of work grow, some older applications become of less importance and in some cases pass out of the picture entirely. There was a period not so long ago when considerable time was spent in engineering colleges on the design of wooden framed structures, stereotomy, shades and shadows, valve gears, steam engine design, boiler design, and even Greek and Latin. Such courses have been replaced in most cases by new developments. Mr. Boring of the General Electric Company recently said,* "If engineering educators were to make a change in their curricula based on the employment which the big companies expect to offer, they would drop any courses dealing with electric railways, etc." This shows the trend of the times.

* S. P. E. E. JOURNAL, Oct., 1934, p. 136.

The dropping of obsolete material from the educational program and adding new courses will continue; such questions, however, should be considered very carefully lest the main objective of the curricula be weakened. There may be also too much emphasis placed on new developments with the result that the curriculum may become decidedly narrow and onesided. For the undergraduate course I believe the work should be almost entirely fundamental. I mean by this that all courses should present material of a type which will open up new fields of knowledge or perhaps develop a new subject based on known principles.

If we examine the new courses being offered under the industrial engineering and management options or curricula in various schools, we find that most of the material can be divided into the following general groups:

1. Economics including accounting, cost systems and finance.
2. Production methods and manufacturing plants.
3. Labor problems or in a broad sense human problems.
4. Management problems.

I believe no one will question the value of knowledge in these fields to an engineer, and I know that the instruction in these courses in many cases is of a very high order.

It is also interesting to note that if we inspect the curricula of business administration courses being offered by some of our well-known universities, we find courses listed by these same names. Now are we trying to teach business administration, or are such schools trying to teach engineering? I would say neither. There is a very definite place in our education system for the schools of business, but I am convinced that it is the job of the engineering schools to apply engineering methods to the solution of production, distribution and management problems in technical industries.

A good general course in economics would be worth while for engineering students; however, the type of economics and cost accounting that the engineer needs is somewhat different from the courses in economics and cost systems usually offered by schools of business. Production methods and control become quite a definite procedure to the engineer rather than abstract generalities, and such courses are usually built on a knowledge of shop practice. The engineer has also demonstrated that the operation and management of industry should be carried on according to methods and principles which can be analyzed, and which can be prescribed and taught in engineering colleges.

Recognizing now that new methods and technics have been developed for the operation and management of industry and that these new technics should be taught in our engineering colleges,

the question arises as to what students should receive instruction in these new fields and how far we should go in teaching such work. I think that every engineering graduate would profit from some instruction in these new fields, and I believe this will be recognized in the near future. Technical education should not long remain separated from economic and human problems if we face the situation fairly.

A group of courses should be offered dealing with the fundamental principles of industrial economics, manufacturing methods, cost analysis, and principles of organization and management which should be open to all engineering students, and the schedule should be arranged to permit any qualified students to elect these courses. Since the large majority of mechanical engineering graduates attain responsible administrative positions in industry, all of them should be required to take a reasonable amount of such work and the curricula should be flexible enough to permit a well rounded program for those students who are interested in this work. I believe this can be done without weakening the present basic engineering courses.

Graduates are not competent designing engineers when they finish college, neither are they expected to be competent production engineers or managers. I believe for undergraduates the courses should deal only with fundamental principles or methods which carry over and which can be applied to new situations.

A point worth noting is that careful records show that many engineering graduates do not accept employment in the special fields stressed in colleges, and also many graduates change both the type and character of their work during the first few years of employment. The education of these young men, therefore, should be broad and fundamental rather than too highly specialized.

The writer believes that the developing of new courses in the principles of manufacturing, industrial economics, and management, etc., should be considered as a broadening of the education of engineers and not as a new kind of engineering to be practiced by specialists.

Education, of course, should meet the needs of the conditions existing. Large institutions may to advantage offer special curricula to meet special cases when they are equipped to do a good job, and when the demands are such as to practically guarantee employment to graduates in the special field. The writer believes, however, that at the present time the demands of industry in general can best be supplied by furnishing graduates well grounded in the fundamentals of the major branches of engineering and including some work in the newly developed fields of manufacturing and management.

METHODS OF INSTRUCTION IN MANAGEMENT AT PURDUE UNIVERSITY *

By G. H. SHEPARD

Professor of Industrial Engineering and Management, Purdue University

Frederick W. Taylor began the transformation of management from an art to a science and gave to his doctrine the name "scientific management." I assume that you will agree with me that, in so far as any science has truly apprehended and correctly applied the laws of nature, it is universal in its own field.

The success of scientific management during the last fifty-three years in many and diverse applications demonstrates that it has truly apprehended and correctly applied the laws of nature in the field of management.

At Purdue the foundation of our methods is therefore the conviction that the science of management is universal; that is, that it applies to the student's management of himself and to God's management of the universe and to everything in between.

As in the practical application of any science, the practitioner can deal successfully with the infinite variety of situations which confront him only by doing his own thinking on the basis of fundamental principles. Our teaching of management therefore has two immediate objectives:

Indoctrination of the student in the principles of management, and

Practice in the practical application of the principles.

We begin with the student's management of himself. In the sophomore year he is offered a course in personal efficiency,—Principles of Management and how to apply them to himself. How can he later plan for a business, if he can not plan for himself? How can he better make the acquaintance of the budget, than by budgeting his own income and expenses? In this course the goal of an immediate personal efficiency reward in the shape of greater achievement is kept prominently before him. He is encouraged also to seek those opportunities for managerial work in student activities and as a non-commissioned officer in our Reserve Officers' Training Corps, which in his sophomore year begin to open to him, and in work in industry during the summer vacations. We try to

* Presented at Conference on Industrial Engineering at Madison Meeting, S. P. E. E., June 24, 1936.

impress upon him that management is not something about which he is to store his mind with knowledge for use at some future date; but that it is something which life demands of him here and now.

In a student's junior year he is offered a course in the application of the principles of management in business and industry. This course is intended both to give him general knowledge of the subject and to guide him into further specialization, if he finds himself interested in management.

In the senior year more advanced and specialized courses in management are offered. These courses may be briefly summarized as follows. First is a course in General Accounting; then Personnel Administration; Industrial Design, in which the students design a factory and management system for some product of our own shops. The reason for basing the course on our own products, is that the students may already know the processing and be able to devote their study to the problems of management. This course is required of students who take the industrial option. There is a course, required in the industrial option, in Cost Accounting. After giving this subject for several years as a text-book course, I concluded that students did not get a practical knowledge of cost accounting by that means and have since given the subject as a design problem, in which the students design a cost system for some small unit. My ideal in this course is to make cost accounting a tool of the manager.

In my association with Harrington Emerson I was greatly impressed by his emphasis on his Four Ethical Principles. Experience since has increased the importance which I attach to these principles. In fact, if we seek for the causes of the depression, it seems to me that the most fundamental is bad ethics. We therefore seek to impress our students with the importance of ethics in management, that the Four Ethical Principles are absolutely necessary to any permanent success, and that, in the hands of a skillful manager, they are as much the means of success and profit as any of the technical principles.

Students in the industrial option are required to take a course in motion and time studies with the stop watch. The first objective in this course is to enable the student to take and hold a position as a commercial stop-watch time study man. The second is to give him such instruction in the principles of motion-economy as will make him a keen observer of such matters and prepare him for motion study with the moving picture machine. The third is to qualify him for what a committee of the Management Division of the A. S. M. E. called "Micro-motion principles with stop-watch technique" and thereby to enable him to do as advanced work in

motion and time study as is possible without the moving picture machine. About three fourths of this course is devoted to practice in making motion and time studies. By the coöperation of industrialists in Lafayette, our students make many of these time studies in commercial shops; and we encourage them to do as much of their practice as possible under actual commercial shop conditions.

There is also a course in motion and time studies by the moving picture machine. In this course the main subject is an operation which the students in the course in stop-watch time-studies have already improved as much as they could by that method. This operation is photographed; and the students in the course in micromotion, study the film and try to improve the operation further. The results are very convincing as to the superiority of the micromotion method. Studies are also made of selected films from our collection of such films from industry.

There are also courses open to graduates in engineering, in which the student may undertake any project in management; and the projects which have been undertaken by them have been of the widest variety. Work in these courses is entirely individual and is limited only by the opportunities available. Work in these courses may be done in absentia. Students may also do theses in management in partial fulfillment of the requirements for all degrees from the bachelor's to the doctor's.

All of our senior engineers are required to take a course of three semester hours in engineering administration. Two semester hours are text book work on Tucker's "Contracts in Engineering." The other hour is devoted to lectures by distinguished engineers, usually non-resident.

In 1935–36, Lillian M. Gilbreth was appointed non-resident Professor of Management. Capable senior and graduate students, not only from the schools of engineering, but from all the departments of the university, are admitted to her instruction. Her method of work is by individual projects. These have been of the utmost variety. One young woman from the Department of Psychology is working on the measurement of mental attitudes. A senior mechanical engineer worked out a new outfit of machine tools for a plant manufacturing an automobile accessory.

In the second semester Dr. Gilbreth started a non-credit course in motion and time study. This class is working in advanced research on the fundamental motions, or therbligs. Dr. Gilbreth's work is in process of development. She is reaching out at present for contacts with neighboring industrialists, with whom we hope to coöperate to mutual benefit.

Consistently with our fundamental conviction that the science of management is universal, we try to send our students into the world with a realization that our present economic ills are the result of bad management; and that it is preëminently the duty of the engineering profession, which has had during the past fifty-three years an experience in management which no other profession has had, to lead the way in the development of a science of social economic management which will give to our people the full benefit of their ability to produce.

REPORT OF COMMITTEE ON TECHNICAL INSTITUTES, JUNE, 1936

Two years ago, at the Cornell Meeting of the Society, the report presented by this Committee called attention to some of the more important features and characteristics of American Technical Institutes; and especially to the boundaries or lines of demarcation of the three different and prominent fields of technical education.

The three fields referred to were:

(*a*) That of the typical four-year, full-time, degree-granting course.
(*b*) Extension instruction of various kinds.
(*c*) The field of the Technical Institutes of America.

And emphasis was placed upon the helpfulness to all concerned of having the distinctive and important characteristics of each of these three fields clearly understood by everyone interested in technical education. Also a good deal of evidence was submitted to show that in the personnel that naturally selects the latter field there is a surprising percentage of superior talent and dynamic leadership.

In the former report, too, the Committee called attention to the fact that courses of instruction in the technical institute field have been relatively short. They are usually less than four years in length and, more often than not, but one-half that length. This limited time within which to obtain a definite result, and within which to enable students to secure a dependable foothold in some department of industry has encouraged these schools to be pioneers in many ways.

And especially it has made it important for them to consider:

First: New methods of determining the specific talents and capacities of applicants for admission to courses of instruction and evidence of probable ultimate fitness for success in particular fields of work or callings—in contrast with tests planned to evaluate previous schooling.

Second: The discovery and analysis of the specific qualifications for success in the callings or goals toward which students were aiming.

Third: A direct, efficient, and scientifically organized curriculum or pathway along which the student may proceed from where

he is found to be at the time of his entrance, with minimum delay or hindrance, toward the goal to which his ambition leads him.

In the search for the best procedures in these three directions, the technical institutes have realized their rare good fortune in freedom from those restricting traditions and conventional practices which often hamper more standardized types of institutions.

The report referred to further includes the facts that a large part of the instruction is individualized and is adapted to special needs of particular students; that it is usually related to selected specific, and often non-inclusive, goals; that the instruction is usually kept flexible so that it may be repeatedly adjusted to fit the changing requirements of industry; and, great pains are usually taken—and often with a marked degree of success—to foster the development of a strong and well-rounded personality.

A few illustrations emphasizing these several points that have been drawn from the practice of some of the well-known technical institutes will prove of interest:

Dunwoody Institute of Minneapolis and Rochester Athenaeum and Mechanics Institute accept students at any time during the school year, and great pains are taken to arrange the instruction so that students will lose nothing by their entrance at dates best suited to their own convenience, rather than at the date fixed for the opening of a school year. The latest catalogue of Rochester, for example, is conspicuously entitled on its cover an "Individualized Educational Program." Other illustrations from other schools might be given, for most of them call particular attention to the pains that they are prepared to take, in order to fit the needs of each student, instead of expecting the student in every instance to adapt himself to the conditions of the standard program.

The specific character of the teaching in the technical institutes, and the marked trend toward developing their own techniques and methods of instruction is seen by the wide application of what is virtually the "Case System" of teaching, in contrast with the more traditional lecture, recitation, and text-book methods. Frequently, courses have been developed from job analysis, or have been built up by teachers whose contacts with employment in particular industrial fields are extremely intimate. The same ideas are further illustrated by the willingness to disregard the usual and accepted academic practices, both in selection and arrangement of subject matter and in teaching procedures, when promise of better results is clearly indicated.

Keen interest in individual characteristics and differences of students is continuously manifested in the technical institutes. It would be most instructive, if time permitted, for us to give a de-

tailed description, in one or more typical places, of the way in which each student is examined and tested, in order to get every possible insight into his probable capacities and aptitudes. Several of the schools, Rochester, Wentworth Institute, and Franklin Union, in particular, accumulate quantities of "behavior anecdotes" from all their applicants, often going back many years and taking care to phrase these in a way that will reveal their educational significance. The liberality of other schools, like Pratt Institute, in generously accepting equivalents and in placing the emphasis of their tests upon "aptitudes," "comprehensive intelligence," "purposefulness," and "promise of successful employability in the field which they desire to enter" again emphasizes the intense desire to study individual differences and special abilities of students before attempting to prescribe a program of training for them that will promise to be of most effective service.

The habit of developing courses of instruction to meet the needs of particular localities and of offering courses leading to specific goals is rather strikingly shown by a course in gas manufacture and illuminating engineering at Dunwoody Institute and by courses in scientific baking, milling and sweet goods at the same institution. Again, we find elaborate equipment and preparation for training in printing industries at Wentworth Institute, photography at Rochester, and pharmacy at Franklin Union, a course in co-operative power laundry at Ohio Mechanics Institute; chemical technology, with special reference to paint manufacture, curing and tanning of hides and leather, manufacture of soaps and dye-stuffs at Pratt Institute. And again, aircraft construction and design at Wentworth Institute. These examples just quoted are, of course, outside or in addition to the more usual courses included within the scope or of the curricula of the schools just mentioned.

The final point that was emphasized in the last report of the technical institutes was success in developing strong and well-rounded personalities. Again, we wish that space permitted us to offer evidence that is available to sustain this statement.

The School of Science and Technology at Pratt Institute publishes a directory of its graduates with statistics of positions and earnings, and the catalogue of the school invites comparisons between the information contained therein and the corresponding data regarding "the careers in industry of graduates of this country's representative schools and colleges of engineering." In view of the difference in length of courses of instruction at Pratt Institute and those in the other fields of engineering education, this is a bold challenge. But it is one, apparently, that the authorities of Pratt Institute feel sure they can sustain.

Similar statistics from other institutions would, however, aid them, we believe, in establishing their contention. We note here, too, in this connection, the recognition that has continuously been given, and entirely unsolicited, by the American Society of Mechanical Engineers and the American Institute of Electrical Engineers to graduates from several of the well known technical institutes; this striking evidence in the direction of Pratt Institute contention.

A great many more illustrations could be given, drawn from the practice of these schools, if space permitted, that would still further supplement the ideas given in the report of two years ago and that might, also, perhaps help toward a wider and better understanding of the aims and purposes of the different technical institutes in the United States. But perhaps enough has been said to illustrate and make plain what Dr. Wickenden had in mind when, in his report on "A Study of the Technical Institutes," in June, 1931, he emphasized the blessings that these schools had enjoyed through being "spared a narrow regulation," and also when he referred to *"the benefits that come in educational methods and procedure through unhampered pioneering."*

Fruits of Pioneering

In the latter part of that report, attention was called to a number of ideas and successful practices that also had been evolved through the experiences and experimenting of the technical institutes. They, too, are the product of the kind of pioneering that Dr. Wickenden has referred to above, and they were put forward in the hope that they might prove of interest to persons engaged in other fields of technical teaching.

During the past years, the Committee, in correspondence with its own members and with others, has received many suggestions for supplementing or expanding some of these ideas. It would be inappropriate to take time to include many of them here and it is difficult to make a selection. One, however, has been chosen for presentation with some detail.

The Appropriate Scope of Technical Education

The technical institutes, perhaps more than schools in other fields of technical training, have been brought in contact with the problem of cultivating the technical and industrial intelligence among the workers of all grades and on all levels in industry, from the beginning of apprenticeship, all the way through the ranks, from the bottom to the top, to persons in controlling management

who require perhaps some specialized advanced instruction. This experience has forced them to consider and study the inclusive field. The importance of all parts of it has impressed them. Fragments chosen here and there do not suffice.

In consequence, the feeling has grown stronger that the entire engineering profession, continuously throughout the years, has missed one of its greatest opportunities for service to its own profession, to American industry, and to our nation as a whole, by its failure to place emphasis upon "Adequate Training throughout the entire Personnel of Industry from Top to Bottom, including Everyone connected with every Technical Industry or Engineering Occupation."

The profession might well have made this one of its major programs and plans of action. It is true that in recent years more or less attention has been given to the matter of "human relations" in connection with the industries. But, almost without exception, wherever and whenever this has been done, it has been *not* with the idea of developing finer and broader and more intelligent men throughout the ranks; but rather, almost invariably, upon the assumption that the intelligence and attitudes of the workers were, in large measure, definite and fixed quantities; and that this was the problem of the administration's adapting its policies in these ways and directions that would be least likely to encounter opposition or resistance. And the profession has appeared to be concerned only with the engineering and administration features of such problems.

Attention upon fostering the idea that industrial management is one of mutual understanding between workers and administration and one of common issues and problems in which all workers and administrators are co-partners, with a common stake in the outcome, appears to have been largely overlooked. There have been, of course, a few notable exceptions:

About thirty years ago, a paper appeared in the transactions of the American Society of Mechanical Engineers by Mr. Wolfe describing a notable experiment that he had been carrying on in his plant. He endeavored to make every task assigned to every workman, in one way or another, an educational project and sought to have every foreman or supervisor a teacher who was helping the men, for whom he was responsible, grow in skill, in technical intelligence and in understanding of the purposes of the employing industry, as well as in desire to coöperate with it. And he discovered that the satisfaction of his men, arising from a confidence that they were continuously growing and developing was an incentive, urging them to do their best which was quite comparable with substantial increases in their pay.

Again, Fred Taylor continuously tried to broadcast this idea. His philosophy, briefly stated, is:

(*A*) There's a best *way* of doing every job.
(*B*) There's a best *man* for every job.
(*C*) There's a best way *to train* every man.
(*D*) There's a best way to create the most desirable *incentives* in every man.

And Mr. Taylor believed that the kind of educational experience—to which we have just referred in Mr. Wolfe's experiment—was one of the best ways "to create the most desirable incentives." Unfortunately, Mr. Taylor's disciples all appear to have forgotten entirely this most important part of his philosophy.

In contrast, not long ago a paper was presented at one of the national society conventions by a very intelligent superintendent of one of the largest plants in the United States. It described his program of "Apprenticeship Training." When the speaker had finished, he was asked: "How many young men were included in the plan?" His reply was: "Sixteen." It ought to have been three or four thousand. It is very nice, of course, to be kind and considerate to sixteen "special pets" of management. But is management living up to its real responsibility when it does not include in its training programs ninety-nine per cent, instead of a fraction of one per cent, of the men for whom it is responsible?

And again, is our profession of engineering living up to its responsibility when it does not, in season and out of season, continuously call attention of management to its responsibility in this regard? And ought our profession to have stimulated continuously, during the past thirty years, studies, investigations, and experiments, in order to refine, develop and better the methods and procedures that Mr. Wolfe reported on, and that Mr. Taylor advocated? It should be noted that very many prominent engineers are in cordial accord with the views we have just expressed and would answer this question with an emphatic "Yes."

Now, if we are right in feeling that our profession might well enlarge its view of its responsibility to the entire personnel of all engineering industries and occupations, is it not a fair question to put up to this Society for serious consideration; likewise to enlarge the scope if its responsibility and feel that it has a national duty in fostering every kind of technical education at every level to a far greater extent than it has ever done?

Other professions appear, to a large extent, in their interests and in the range of their activities, to be thus all embracing. Are engineering and engineering education to continue their relatively narrower outlook and more limited sense of responsibility?

The Conflict between the Curricula Regular and Education

In the extended correspondence that this Committee has carried on during the past years and the many conferences that have been held at different times with different teachers of engineering, the Committee has been interested to discover a rather surprising unanimity of opinion upon some of the fundamental questions that underlie the curricula of practically all the regular courses of degree-granting grades.

Everybody appears to be aware of the general custom of the engineering schools throughout the country of graduating a most unreasonably small proportion of the students for whom they have accepted responsibility. People generally seem thoroughly familiar with facts that Dr. Wickenden brought out in the report, which indicate that seventy-two per cent of the students who are admitted to these courses are doomed to failure of graduation within the prescribed time. And there is conviction that this condition has not been materially altered since the report was published.

Of course, it is the conventional habit to place the blame for this situation upon the preparatory schools or upon the students, claiming that either by nature, or by lack of previous preparation, they are not fitted or entitled to succeed in the courses of training they have undertaken. On the other hand, in private conversation, almost everybody appears to know that such claims are neither fair nor true; most of the persons, especially those in positions of responsibility for large groups of students, appear to be conscious that in innumerable instances serious and entirely unnecessary disappointment and human loss result.

There is such extraordinary contrast between the records and percentages of promotion and graduation in many of the technical institutes and the corresponding figures for promotion of students in the curricula of the schools just referred to, that the Committee has wondered if the Society would not welcome at this time a discussion and a study of the causes of these differences.

There is some interesting history back of all this. In very early days, when engineering courses of college grade were first organized, educational methods and procedures were based upon a philosophy quite different from what has become the accepted practice of the last generation. Nothing had then become standardized, crystallized, or fixed. Teachers of engineering were then pioneers in a new educational field, free to experiment and to test one method against another; and were enterprising in their search for the best ways. In the beginning the laboratory method was being evolved. And the teachers were finding there the opportunity to

study their students individually and fit their instruction to the students' capacities and their needs. Then, little by little things changed. Today we find that the educational practices that were adopted by the pioneers of engineering education in large measure have disappeared.

Perhaps this was natural. After a time the technical schools began growing so rapidly that teachers in sufficient numbers with a broad outlook and pioneering spirit were unobtainable. For such subjects, as mathematics, physics, chemistry, and the other natural sciences and, for related courses in language, history and economics, teachers had to be gathered from whatever sources they might be obtained. And these men usually brought with them the academic tradition of their previous environment. They appear to have adhered to it most tenaciously; and those of their pupils who entered engineering teaching shortly after graduation have followed in their train, fearing to venture forth beyond their depths into untried waters of educational procedure. Thus, the academic tradition has become fixed and is today very largely the engineering tradition.

These views are not original with, or the property of, the members of this Committee. The Committee is simply describing a situation which appears to be generally recognized and accepted. It would be presumptuous for us to suggest a remedy or solution. We urge, however, discussion, study, and investigation, test and trial, until the best ways out are found.

This Committee believes, however, that more of the old pioneer spirit should return. We know that we have found pioneering enterprise to be stimulating and helpful within our own field, and, from analogy, it is reasonable to believe that it would be of equal value perhaps in other fields of technical teaching. If we were to offer a few suggestions for discussion, they would be:

(*a*) To substitute for the rigid requirements of the typical four-year engineering curriculum a far more flexible educational program.

(*b*) To test all educational procedures, including the evaluation of candidates for admission, the evaluation of the goals of their training, and evaluation of every step of the educational process of the curriculum as scientifically as possible using the best educational instruments for measurement that have thus far been devised.

(*c*) To rebuild a new type of curriculum adaptable to changing conditions and to individual requirements of different students, in accordance with such findings even though it might require us to turn the usual curriculum upside down; to

begin with the practical handling of the kinds of equipment commonly found in laboratories for senior instruction; to build upon this experience and proceed from that toward the sort of general and abstract teaching that we are familiar with in the usual theoretical courses.

Is not the time ripe for some enterprising institution to break away from the time-honored tradition that fails seventy-two per cent of the students drawn from the top third of preparatory school classes, and try some such experiments as these?

The reward for so doing, this Committee is convinced, would be astonishingly great.

In conclusion, it may not be inappropriate to include an anecdote in which Professor Henry H. Higbie, Professor of Electrical Engineering at the University of Michigan, a member of this Committee two years ago, and Dr. Charles W. Eliot were the principal actors. The scene was in Professor Higbie's electrical laboratory at Wentworth Institute, in the year that school was first opened. President Eliot had just returned from a trip around the world and was anxious to examine what was then the newest experiment in education. He had come to the school quite early in the morning, but his study of what was going on held him until late in the afternoon. He was greatly interested in what Professor Higbie was doing with a class of beginners in applied electricity. The students had had no previous instruction in electricity. Many of them had not even studied high school physics but, nevertheless, they were handling elaborate and complete equipment and full-sized electrical machinery. From their observations and experience, they were getting the data from which to deduce relationship between speed and voltage, Ohm's Law, and the rest of the simple ideas that are appropriate for beginners. Dr. Eliot questioned the students at length and was fascinated by the responses that he got. But he concealed this from Higbie, and turned to him with the remarks:

> "Don't you know you are violating every generally-accepted principle of engineering teaching?"
>
> "Don't you know that it is considered improper to permit students to handle such equipment without previous instruction in theory?"

To which Higbie replied, that he knew that what he was doing was not usual, but that he was satisfied with the educational results that he was obtaining.

Dr. Eliot, appearing not yet to be convinced, remarked:

"But don't you find that the breakage and damage to this expensive equipment is excessive when handled by students who haven't been taught any of the principles first?"

Professor Higbie explained that he had kept careful records of damage and breakage at the University of Michigan with juniors and seniors, and that he had kept the same kind of records since he had been at Wentworth Institute; and that he found at Wentworth Institute the cost of breakage per student to be quite a small fraction of what he had become accustomed to at Michigan.

Dr. Eliot threw off the garb of pretense, clapped his hands gleefully, and remarked: "I knew it! I knew it! I knew it!"

Respectfully submitted,

WALTER B. RUSSELL, *Chairman*
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PUBLIC EDUCATION IN RUSSIA

RESULTS OF A PERSONAL VISIT TO THE USSR.

BY RUDOLF SEIDEN, C.E.

Kansas City, Mo.

TRANSLATED FROM THE GERMAN BY W. H. PEEL, JR.

Public education in Russia is still in the evolutionary stage; with regard to curriculum it has, as yet, taken no definite form. It often happens that in the same school-type will be found entirely heterogeneous courses of study. Some developments in the right direction, however, are worthy of mention.

Since 1932 compulsory education has become universal throughout the entire Soviet Union. *The technical schools are recognized as the most* important and the most advanced. The curricula are devoted to the development of specialists; that is, *students there are given little general background, but instead receive intensive training in narrow fields of their choice.*

What is, for example, the training given a Russian child who wants to become a chemical engineer? This question was the basis for the writer's personal visit to Russia and it will be answered shortly.

At six or seven Russian children become of *school age* and are required to enter an *elementary school,* which they attend for seven years. They then enrol in a *technical school* having many highly specialized departments. So it is not possible for the student to receive there a course in general chemistry; he must enrol, for example, in the department of coke-chemistry, or fat-chemistry, or oil-chemistry, etc. Upon completion of the elected course (four years) the student becomes eligible to pursue his studies further in one of the technical *universities,* which, as previously mentioned, have departmental faculties.

One of the best-known Russian universities is the *Mendeléeff Institute* of Chemistry and Technology in Moscow, where the writer often had occasion to speak with professors and students. The course of study here lasts four years and is divided into twelve trimesters. The Mendeléeff Institute has two main divisions—the Chemical-Technical and the Mechanical-Chemical departments. Each of these is subdivided into faculties, as Sugar, Dyestuffs, etc. In the Chemical-Technical department, the students study chemical processes and theory; their colleagues of the Mechanical-Chemical

department, however, study machinery and apparatus. This is very different from the curricula in most European and American universities.

While observing the school system in Russia, the writer believes it possible to say that graduates of Russian universities are as well versed in the practical relations of their *narrow* branch as in the theoretical. And considering the fact that Russia needs to produce as many engineers as possible in the shortest possible time, the narrow, intense training of these engineers is somewhat justified. However, the fact should not be overlooked that *the Russian engineer,* for instance, *is less informed concerning general questions* and in the relations of chemistry and technology than are American or European engineers.

Many of the university students are not graduates of the technical schools. These have spent much time in actual practice. A three-year preparation course is required of them before admittance to a university is granted.

Examinations are dispensed with in Russian universities, but assignments are not. The instructor evaluates the progress of his students by their recitations and discussions. Low-ranking students, however, must take examinations. If they are thus shown to be incapable of carrying on the work, the matter is taken up by the faculty and they are dropped from the university.

The state and the industries contribute to the Russian university students a reasonably high, monthly scholarship. A state regulation requires that 70 per cent of all university students must be workers or children of workers and allows only 30 per cent from all other classes.

In Russia to-day there are, in the writer's opinion, *about 170,000 public schools with more than 660,000 teachers and over 26 million pupils.* These figures may be compared with 106,000 schools, 250,000 teachers, and 8 million pupils for the year 1913–14. There are also *about 800 colleges and technical universities with* an enrolment of *about 550,000 students; more than 3500 technical schools with over 800,000 students;* nearly *950 workers' faculties* (extension courses for workers) with perhaps 370,000 students; and more than *3900 factory and shop apprentice schools* with nearly 1 million students.

THE PHYSICIST-ENGINEER IN RESEARCH AND INDUSTRY *

By DAYTON ULREY

Westinghouse E. & M. Company, East Pittsburgh, Pa.

In order to narrow the scope of the subject assigned me and because of a wide divergence of opinion, not only between industrial leaders and college scientists, but even between different research physicists, as to the proper meaning of the words "Physicist-Engineer" and "Research" I find it necessary at the outset to give answers, however arbitrary, to the questions, "What is Research?" and "What is a Physicist-Engineer?" This is not with the thought that these answers are preferable to many others offered elsewhere but merely to set down my own limitations with which the subject is treated in what is to follow.

What is Research? One college professor told me his research (accent on the first syllable) consisted primarily of searching again for the apparatus his colleagues had borrowed; Kettering is quoted as having said, "Research is a state of mind"; Mees has defined it as "investigation of the relationship between cause and effect in natural phenomena"; Jewett says "All research is merely orderly investigation." For the purposes of this paper, however, research is defined simply as scientific investigation involving the application of available knowledge in the quest for new knowledge. It is immaterial whether the sought-for knowledge is expected to be of scientific interest only or merely to have practical value. Industrial research, that is, research carried on by and for industry, does not differ in any essential features from that done in the university though in the first case the end expected, or at least hoped for, is invariably, directly or indirectly, a practical one, whereas in the latter the object is, in general, solely one of adding to the store of scientific knowledge.

What is "The Physicist-Engineer"? This hyphenated object, as thought of today, is only a youngster beside the aged physicist and the middle-aged engineer. He is, as the name implies, one trained as a physicist who applies his efforts in fields of engineering. He is decidedly not yet the finished product of any educational institution. Rather, he is what industry has created and is

* Presented at the Conference on Physics at the Madison Meeting, S. P. E. E., June 24–25, 1936.

creating to meet its growing needs. He is a hybrid, developed in the industrial laboratory, to do a job which neither the so-called "pure physicist" nor the engineer is qualified to do. This development usually consists in placing the physicist in such surroundings that he acquires by absorption, by extension, and even by having grafted on the engineering element. The alternative of starting with an engineering graduate and then developing him as a physicist, is of course also practiced and has produced some of our best physicist-engineers.

Within the last several years there has apparently been a rather sudden awakening by college physicists to the realization that industry is finding need in its research laboratories for a considerable number of their former students, particularly those who have done several years of graduate work. In fact most of the older industrial research physicists are themselves former college professors. But the colleges also realize that industry is assimilating this diet only with what appears to be undue mastication and considerable indigestion and they are now properly concerned as to what they may do to improve this situation.

It should be mentioned in passing that there are other causes for indigestion besides improperly prepared food—the patient may be suffering from other complications—but aside from this, there is still cause for concern. Recent indications of this interest, aside from the present program, may be found in the following: The American Institute of Physics has organized the Advisory Council on Applied Physics * to consider this and other phases of the subject, and will hold its third meeting in October of this year; the London Institute of Physics † held a meeting in February of this year to discuss the training of Industrial Physicists; the University of Pittsburgh has during the last year made a survey of the needs of many industrial laboratories with a view toward modifying or extending its courses for students who expect to go into industrial physics; The Pennsylvania Conference of College Physics Teachers is holding a meeting in October at Penn State College and will discuss among other topics "The Training of Physicists for Industry"; several universities ‡ within the last year have announced special courses adapted particularly for students expecting to enter industrial physics. There can be no doubt as to the sudden widespread interest of the college physicist in producing a physicist-engineer. The cause of this interest is less certain but is probably

* *R. S. I.*, March 1936.

† *Journal of Scientific Instruments*, May 1936.

‡ *R. S. I.*, April 1936, p. 196; *R. S. I.*, May 1936, p. 223–224; Calendar of University of Toronto, Faculty of Applied Science and Engineering, 1936–37, pages 40–46.

a combination of several factors: First, the college professor feels a natural missionary zeal in spreading the gospel into new heathen industrial realms and in expanding and consolidating his influence in already converted industries; second, in thus aiding the various industries and society in general he finds a greater demand for the output of his educational factory and incidentally thereby creates an indispensability of his own services therein; and, third, he is convinced that he can improve on the methods now employed, and probably the product developed, by industry for itself.

With certain minor reservations I believe all three of these reasons are logical and valid. But I am also of the opinion that this concern of the teaching physicist is partly due to an impression that the physicist-engineer is more of an engineer and less of a physicist than is really the case. In other words, there is a tendency on the part of our teachers of physics to distinguish *too* sharply between the interests and requirements of industrial physicists and those of teaching physicists. *There is, after all, no substitute in any field of physics for a thorough grounding in fundamental laws and principles* and this is the first and most important responsibility of the university in providing the technical preparation of the physicist, whatever his future field is to be.

This training is not and probably can not be satisfactorily accomplished during the undergraduate period and must therefore be extended in the graduate work particularly to include fundamentals of atomic and molecular structure, of radiation, of quantum and wave mechanics, of gaseous conduction, of surface phenomena, etc. With this is involved a solid mathematical background and a fair knowledge of chemistry, particularly physical chemistry.

That you may be assured that this view as to fundamentals is shared by leaders in Industrial Laboratories let me quote from a few of these:

"I am inclined to fundamentals increasingly, as these with an imaginative mind are the tools which will be used."—Dr. Morris, Republic Steel Corp.

"We endeavor to obtain men with good fundamental training rather than experience in any specific field."—S. W. Davidson, Eastman Kodak Company.

"Such training [for industry] to my mind can be accomplished only by emphasizing the fundamental physical principles . . . ."—John Mills, Bell Telephone Laboratories.

"The most important requirement is that a man should really know the fundamentals of the subject he is studying. If he is a physicist, he should really understand his Physics, ..."—Dr. C. E. K. Mees, Director, Eastman Kodak Company.

Assuming that the prospective physicist-engineer's curriculum is such as to provide for a satisfactory acquaintance with the fundamentals of physics, how and when is he to acquire the engineering attitude and aptitude? At present, except in rare cases, this is picked up over a period of years through interest in and necessity imposed by the research projects on which he has worked and through association with experienced engineers to whom he must sell his results. In laboratories of smaller companies this acquisition is of even more importance because the research cannot be turned over to an engineering department for final development but must be brought more nearly to commercial form by the man who has carried out the research. The physicist would therefore no doubt much earlier merit the name of physicist-engineer if, during his university career, the rudiments of engineering, at least, constituted a part of his formal training. This should include something of mechanical drawing, of shop practice, of study and test of machines. How such courses are to be introduced without dropping others now considered as requisites for graduation is a problem for the college physicist. This idea has been advanced to a considerable degree at M. I. T. where Dr. Harrison,* recently appointed Director of Applied Physics, plans to introduce this fall a group of courses in applied physics. It is announced that "more time will be devoted to chemistry, metallurgy, and the fundamentals of electrical and mechanical engineering. The course supplements rather than competes with the long established course in pure physics, which goes farther into the speculative aspects of science. Thus there will be no sharp distinction of staff, subjects or students between the two fields of study, for under the new plan students will be able to follow their inclinations and aptitudes in one direction or the other through proper selection of their elective courses."

The other idea of molding a physicist-engineer more around the engineer than the physicist is being tried out at the University of Cincinnati where Dean Schneider, Director of the Institute of Scientific Research, has announced "A Coöperative Plan for Training in Basic Industrial Research." † In this plan a coöperating industry, maintaining its own research laboratory, will pay the University $1,200 per year for each of two students, graduates of first class engineering schools, who will alternate on a six months basis between the industrial laboratory and the Basic Science Research Laboratory of the University. In addition, the industry will pay the prevailing rate to the student for the six months he spends in its industrial laboratory.

* *R. S. I.*, April 1936, p. 196.
† *R. S. I.*, May 1936, p. 223–224.

Another plan which has already met with considerable success, but which is not practicable elsewhere to a similar extent, except in a few favored locations, is that known as the University of Pittsburgh-Westinghouse Graduate Program.* This has been in operation for about ten years and consists essentially of a coöperative arrangement whereby employees of Westinghouse who are graduates of accredited Colleges and Universities may take advanced graduate courses under the instruction both of prominent Westinghouse Engineers who have appointments on the staff of the University, and of regular members of the University staff. Under this plan a number of young men, some trained as engineers and some as physicists, thus find it possible to supplement their preparation with advanced training particularly suited to the specialized field they have chosen.

Obviously there are limitations to which applied physics as practiced or required by industry may be taught in our schools. This is particularly true since among the teachers of physics there is practically no one who has served even an apprenticeship in an industrial laboratory. A number of former college teachers of physics have joined industrial research laboratories but thus far this seems to have been, except in rare instances, an irreversible process. Is it not time that those departments of physics which would give heed to industry's needs for physicist-engineers take a leaf from the book of our engineering departments? I believe it is not uncommon for our better engineering departments to look among leading engineers of practical experience for candidates to fill vacancies when such occur in their teaching staffs. Experience has shown the wisdom of this procedure for industry as well as for the school. Should the case be essentially different with reference to industrial physics?

Other solutions to the general problem have been advocated and are being tried out. The most meritorious of these also involves some arrangement whereby the prospective industrial physicist spends a portion of his time in one or more industrial laboratories before completing his college work. For example, in furtherance of such a program the London Institute of Physics † now announces that it is able to assist registered students of the Institute in obtaining positions in industrial laboratories. This is, I believe, in an unpaid capacity. That many students in this country appreciate the value of such a plan is evidenced by the fact that the Westinghouse Research Laboratories, and I presume many others also, receive numerous requests from undergraduate and post-

* *Electrical Engineering*, January 1934, p. 103–8—H. E. Dyche and R. E. Hellmund; and *Electrical Engineering*, March 1934, p. 446–7.

† *Journal of Scientific Instruments*, May 1936, p. 176.

graduate students for summer employment, some of these candidates offering to work without pay. Some years ago we accepted quite a few such requests—never without pay, however—and though our experience has been none too encouraging in thus developing outstanding industrial research physicists, I am convinced that the results were of great value to the students and that, in the long run, it would be profitable for the laboratories also. In looking back over my own preparation I am convinced that a year spent in one of the leading industrial research laboratories some time during the period of my graduate work would have been of more value to me than a year spent in any other manner. Incidentally, I believe the statement would also be true, however, had I remained in the teaching profession.

Frequently prospective industrial physicists and occasionally college teachers ask us what type of specialization is likely to be most in demand by industry. It seems only natural and proper that industry when in need of an additional physicist would seek one who has specialized in his graduate work in the particular field in which the need is felt. In some degree this is done though I have been somewhat surprised in looking over the Physicist-Engineers in our own laboratories to note how few of them are now working or even began their industrial research in the same field as that of their graduate specialization. If this condition prevails in general in other laboratories it seems to be quite significant with reference to the importance leaders in industrial laboratories place upon particular fields of specialization. I, therefore, inquired as to the situation in other large industrial laboratories and though the tabulation is not yet complete, the returns are sufficient to indicate the trend quite definitely. Of 64 industrial physicists who have completed one or more years of graduate work only 19, or less than 30 per cent, began their industrial research in the same general field of physics as that of their graduate specialization and only 17 of those are now in such a field. Of course there are certain fields such as X-rays, certain phases of electronics, the new field of nuclear physics, and the like where it is unusually difficult for industry to introduce new men who have had no special training in such fields but, omitting these, it is evident that industry places little importance on the particular field of the physicist's specialization during his graduate work.

But there are other qualifications of the physicist-engineer which are of more importance than any yet mentioned and although the University no doubt appreciates the general worth of such traits I question whether the value which industry places on such factors is fully realized. *Mere scholastic excellency in appropriate*

subjects does not make an industrial physicist anymore than a knowledge of the Bible makes a good minister. Our most brilliant industrial physicists are not necessarily our most valuable ones. There is time here only to mention some of the most important personal characteristics of the successful physicist-engineer, characteristics which the University can do much to develop, particularly during the graduate period, but this may serve to show what is meant.

There should be moral and intellectual honesty; honesty in dealing with associates, as otherwise proper coöperation so essential in an industrial laboratory is impossible; honesty in thinking, giving due weight to facts which appear to contradict a "pet" hypothesis as well as to those which seem to support it; and, honesty in imparting findings and conclusions without bias to superiors and to proper associates.

Intellectual curiosity is essential, an insatiable desire to know the answer to "why?" and "how?" It helps to develop interest, even contagious enthusiasm in the work. This attitude is illustrated by the statement I recently heard from one of our men that "This is just what I would be doing for recreation if I didn't have to earn a living."

The habit of dilligence and industriousness may seem a homely virtue but it is basic nevertheless. Too many of would-be physicist-engineers reach industry without knowing what earnest, consistent work means. An industrial research director once told me that he preferred to get men who had been raised on the farm because they had learned the "habit of work."

Ingenuity and common sense make a valuable combination,—ingenuity to devise new methods of overcoming obstacles, and common sense to discern which of these methods are practical. H. A. Wilson had this in mind when he said in recommending one of his graduate students, "His experiments always seemed to work well right away and he never seemed to waste time trying things which would not work."

The relative importance which industry places on these and other personality factors in industrial research is noticed particularly in a depression period when budgets are curtailed and a reduction of the staff becomes necessary. Lack of technical ability is not generally the chief reason that one man is released while his neighbor is retained.*

When you as teachers have found the prescription and specification by which you can develop the physicist-engineer as a more

* "Characteristics of a Group of Engineers," *Electrical Engineering*, December 1934, T. Spooner.

or less finished product, there seems little doubt that the demand by industry for this product will increase very materially. There are two reasons for this. First, in spite of the fact that industry reduced its research budget by about $50,000,000 annually during the first several years of the depression, there is a growing realization of the real value of industrial research, a realization that a sound research program is a guarantee of continued financial stability and, second, there are now many problems, particularly in the smaller industries, for the physicist-engineer which are either being neglected entirely or are being compromised by being put into the hands of chemists, metallurgists, and electrical or mechanical engineers because no one else now seems to be available.

In the meantime the larger industries already owe a considerable debt to the universities for the training of the scientists they have found so necessary for their research and development. Without this, these industries would be forced to undertake a large educational program themselves. With the college training still better suited to industry's needs this debt to the colleges increases proportionately.

THE WISCONSIN PHYSICS MUSEUM AND ITS USEFULNESS IN TEACHING PHYSICS TO ENGINEERING STUDENTS *

By L. R. INGERSOLL

University of Wisconsin

The Wisconsin Physics Museum was started some nineteen years ago, when we moved into our present physical laboratory, and is probably the oldest one of the sort in the country. It was largely the idea of the late Professor B. W. Snow who was chairman of our department for many years. He had been greatly impressed, as have been many of the rest of us, with the great museums of this general sort in Europe, particularly the Deutsches Museum. It was his idea that even a small physics museum would be an eminently worthwhile feature of a physics department. We believe that the experience of the last 19 years with this little museum has amply justified these early predictions. During this period the general interest in it has steadily grown as has also the use we have been able to make of it in connection with our instructional work.

It is particularly its usefulness in connection with our teaching program, especially in the teaching of physics to engineers, that I am concerned with in this paper. The museum occupies a small but strategically important space on one side of our main corridor. Had we thought about it for years we could not possibly have picked a better place, for students naturally go into it while waiting for lecture time and again after a lecture when interest in certain phenomena has been aroused. It houses some 80 exhibits which is about the maximum number which can be accommodated in this space without confusion.

Material on exhibition may be roughly divided into two general classes, of which the first comprises charts, transparencies, wall cases showing manufacturing stages and parts of electrical instruments, etc., some optical apparatus and a number of other still exhibits. Such material requires a minimum of space and upkeep.

Of much greater interest, however, are exhibits which "work." These vary in complexity from the cut-away push-button-operated Ford motor, transmission, and differential, to simple air pressure experiments. Incidentally some of our best exhibits have been gifts from manufacturers. It must not be concluded that automobile and apparatus makers are merely waiting to be asked to

* Presented at Conference on Physics, Madison meeting, S. P. E. E., June 1936.

contribute expensive demonstration pieces, but it is probable that any similar museum which has been in successful operation for a number of years and thereby has acquired some standing would be accorded the same courteous treatment in this respect that we have experienced.

The museum, as I said, occupies an important place in our instructional scheme. In connection with his general laboratory work, every student is asked to study certain things here. Early in the course there is a short and simple discussion of the error curve as applied to experimental work and the student is required to go to the museum and experiment with the probability board. The shots, as they fall between the pegs form a very fair probability curve and the better students, at least, get some idea of the relationship of this to the error curves they have been drawing in the laboratory.

One of the exhibits which attracts very general interest is the Foucault pendulum which swings in a special well designed for it. It moves over a card with time graduations correct for this latitude. It is started every morning at 8 and for the remainder of the day the time can usually be determined from it to 5 or 10 minutes. There is a small rotating table beside it, with miniature Foucault pendulum, to show the connection with the rotation of the earth. The lecturers in the various elementary courses usually discuss the Foucault pendulum, and then refer students to the museum to see it. To insure students actually studying it we require, in connection with one of the laboratory experiments, that every student time this pendulum and compute its length (14.5 meters).

The gryoscope is always of interest, especially to engineers. A weighted bicycle wheel shows all the ordinary phenomena of precesion and a large electrically driven gyro in a box gives striking illustrations of gyroscopic reactions when one tries to "wrestle" with it. There is also, of course, the ordinary turntable to demonstrate the principle of the conservation of angular momentum. When this is used in connection with the bicycle wheel gyro it affords a number of very nice demonstrations, including the principle of the gyro-compass. Further dynamical experiments include reaction balls, a model to illustrate the principle of the platform balance, and a torsion pendulum with which the student is asked to study the dynamical measurement of mass—*i.e.*, as independent of the earth's attraction.

In the field of fluids, we have a few simple hydraulic models. There are also some simple air-pressure experiments, but these are really aimed at the high-school student visitors, of which we have several hundred each year. The Flettner model rotor ship however

interests everyone. This is discussed together with the curving baseball, in connection with Bernouilli's principle.

In the field of electricity the large electromagnet always occupies the center of interest. Perhaps the most useful purpose this serves, however, is to furnish the student a good illustration of eddy currents. He experiments with solid and slotted copper plates, moving them back and forth between the poles. There are several other electrical experiments including repulsion induction rings, one of the relatively new "thermomagnets," and another eddy current demonstration.

In the field of sound we have three exhibits of perhaps more than ordinary interest. The first is a demonstration piece, furnished us through the kindness of the Burgess Laboratories, with which one can study the effectiveness of modern sound absorbing materials. This goes well with one of our laboratory experiments in which the student is asked to test the reverberation period of various auditoriums.

The second exhibit for demonstrating auditory perception of direction is a by-product of the war. During the latter part of the war, a group from this department, headed by Max Mason, then Professor of Mathematical Physics, developed a submarine detector which was being somewhat extensively used at the close of the war and had several "catches" to its credit. This was an elaborate application of the principle of direction perception in terms of the path difference of sound to the two ears. Our museum outfit consists of a simple "compensator" by means of which the sound path to one ear can be shortened while the other is lengthened. As this is done, the sound, as heard with stethoscope tubes in the ears, appears to swing around. To most people the effect is very striking.

The last of the three sound features is one of the first Edison phonographs. We wrote Edison some ten years ago that we had this and he at once sent us one of his latest phonographs, with his compliments. Of course, we did not mean it as a hint, but I am glad that he took it as such.

We have several demonstrations in the fields of heat and light. I must mention the mercury lamp whose spectrum the student studies with the aid of a small hand spectroscope. Perhaps, I should also point out that to secure the most demonstration experiment for the effort, simply set two mirrors at right angles on the wall at the height of the head, as we have done. The double reflection reverses the image so that one—probably for the first time—can actually "see himself as others see him." Reflected printed matter is readable.

Lecturers in the several elementary courses not infrequently make use of material from the museum in their demonstrations.

The student is then asked to repeat the experiment in the museum and investigate its possibilities thoroughly. Instructors also refer their classes to the museum for certain demonstrations, for example, the Cavendish balance, whose use in lecture requires an abnormal amount of preparation and demonstration time. And what student, of any ambition at all, would not rather shift the attracting spheres himself and see gravitation deflect the torsion pendulum, than merely watch a lecturer do it?

All exhibits are accompanied by written explanations which aim at making the fundamental principles clear, even to one who has had little or no physics. A few of the descriptions are rather elaborate. With the aid of the one for the Cavendish balance, the student who is so minded actually can determine roughly the constant of gravitation and thereby the mass of the earth.

The museum is open for five hours a day and is entirely without the services of an attendant save for a few hours a week of attention from an apparatus man or assistant. The room rarely is empty and not infrequently is crowded. While most of the users are students, townspeople are frequent visitors as well. So far (here we pause to take the customary precautions!) there has been no vandalism and little thievery. Breakage has cost only a few dollars a year for replacement. At times the small boy has threatened to become a problem, but only rarely do we have to limit his vigorous experimental activities. Sometimes it has seemed as if wood and metal could not resist the onslaught to which the turn table, loop-the-loop, repulsion-induction rings, or electromagnet is subjected; but after the fray is over everything still seems to be in place and the care with which switches have been opened tends to restore one's faith in humanity in general and the small boy in particular. The museum is by way of being a small scientific Mecca for science classes of local high schools and those of nearby towns.

It is our belief that the physics museum has come to stay as a definite and important aid in the teaching of physics and stimulating interest in the subject. We also feel that any department which in the future plans a new laboratory without including arrangements for such a museum will eventually regret the omission. But lack of suitable space at this time need not deter any department from immediately starting such a collection on a small scale. A corner of a corridor and a little apparatus drawn from the demonstration collection—or, still better, made especially for the purpose—will serve as a good beginning; and if it is changed occasionally the interest in it will keep up indefinitely. Such a start is now being made in more than one college or university in this country.

THE ENGINEERING ECONOMICS CONFERENCE AT JOHNSONBURG

The important thing to note is a slight change of date. It is now planned to open on Friday evening, June 18, and to close after lunch on Saturday, June 26.

President Hammond has added the names of Cullimore of Newark, Kimball of Cornell, Norton of Virginia Poly and Eshbach of the American Telephone and Telegraph Company, to assist the regular committee on economics of engineering in connection with the arrangements for this session.

The morning program is now pretty well outlined with the evening program still largely in the making. Four morning courses are planned:

(*a*) Teaching methods. One day discussions each of economic theory, engineering economy, accounting and industrial management, with two sessions on interrelations and one on "bread and butter economics" and the eighth session still open. Speakers who have signed up to lead these meetings include Lilly of Swarthmore, Grant of Stanford, Norton of Virginia, and Jappe of the Gulf Refining Company.

(*b*) A continuous eight day morning series on industrial economics, half of the sessions to be conducted by Kimball of Cornell and half by Ennis of Stevens.

(*c*) A similar continuous series on industrial management to be conducted under Barnwell of Stevens.

(*d*) A continuous series on industrial psychology under the direction of Uhrbrock of the Procter and Gamble Company.

Approximate arrangement of topics is as follows:

Industrial management: the fields of managerial activities and the increasing difficulty of control, plant location and relocation, construction and layout, equipment and materials handling—selection and maintenance, standards, planning and its subdivisions with control mechanisms, motion and time study, wage, systems, quality and quantity control.

Industrial psychology: job analysis, personnel selection, testing of personnel, rating scales, training of workers, accident prevention, attitude evaluation and incentives.

SECTIONS AND BRANCHES

Minnesota Section.—The spring quarter meeting was held May 17, 1937, at the campus club, with President W. H. Kirchner presiding.

The question of joining the North-Midwest Section of S. P. E. E. was again discussed. The secretary read a letter dated November 27, 1936, addressed to Dean S. C. Lind and signed by H. D. Orth, Secretary, North-Midwest Section. Article VII of the constitution, relating to Sections, Branches and Divisions, was also read. After a brief discussion it was resolved to postpone action on the question until next fall. It was also recommended to the program committee for next year that an attempt be made to obtain a member of the North-Midwest Section to speak to our Section on the organization of S. P. E. E. and the significance of Sections and Branches.

The nominating committee reported as follows:

President: A. J. Schwantes
Secretary: C. A. Herrick
Chairman, program committee: W. H. Parker

Upon motion the above named were declared elected to the respective offices.

John T. Tate now addressed the group on the relation of the Humanities to Engineering. Following the address there was a lively discussion of the subject.

Twenty-five members were present.

A. J. Schwantes,
Secretary

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FRANK A. HEACOCK, EDITOR

Training the Mind for Engineering.—The engineer does his own thinking. He deplores the current tendency to resort to propaganda instead of reason whenever it seems expedient to get things done in a hurry. He is seldom misled by adroitness which tries to divert the unthinking from the way of truth. Instead of groping in a fog of uncertainty or rushing blindly into haphazard experiments, he prefers to analyze the situation that confronts him and to think straight through to the correct solution of the problem. The habit of analysis and constructive thinking is characteristic of engineers.

This valuable habit of mind is a result of engineering education. It often begins with the study of geometry whose logical procedure adapts the youthful mind to orderly, purposeful thinking. Dealing with only two dimensions, plane geometry is limited in its scope. Since we live in a world of three dimensions, it is a natural step to solid geometry which gives a good start in visualizing space conditions. When such thoughts seek expression, engineering drawing provides an outlet for them. By means of related orthographic views it describes exactly the shape and proportions of any object, revealing hidden details and complex interior arrangements. It demonstrates the value of an elastic viewpoint which permits observation from any angle. Its accurate dimensions tell the size and location of all parts of the problem. Thus engineering drawing is the exact graphical language which every engineer must learn to write and read. Reading drawings promotes visualization and gives a sure grasp of the third dimension. Such training develops the habit of constructive thinking along engineering lines while the pencil is busy drafting exact expressions of the thought.

On this foundation descriptive geometry builds a superstructure of scientific method. Here the student learns how to analyze a problem in three dimensions. He acquires the ability to size up a situation from every angle, to appraise the given facts and data, and then determine the information required for a satisfactory solution of the problem. Thus he develops self-reliance, resourcefulness, and initiative, and the habit of thoroughness in thought and action. This mental training makes him a better engineer and a more useful citizen.

NEW MEMBERS

ALLEN, ELBERT FRANK, Professor of Mathematics, Oklahoma A. & M. College, Stillwater, Okla. A. Naeter, P. S. Donnell.

ANDES, AMMON S., Instructor in Mechanical Engineering, Washington State College, Pullman, Wash. F. W. Welch, M. R. Snyder.

BILLEY, PETER R., Instructor in Mechanical Engineering, Pratt Institute, Brooklyn, N. Y. R. B. Dale, W. H. H. Cowles.

BUTLER, ROBERT S., Instructor in Civil Engineering, Yale University, New Haven, Conn R. H. Suttie, C. S. Farnham.

COTTINGHAM, WILLARD S., Assistant Professor of Structural Engineering, University of Wisconsin, Madison, Wis. H. D. Orth, A. V. Millar.

DOUGHERTY, N. W., Professor of Civil Engineering, University of Tennessee, Knoxville, Tenn. Re-instatement.

EHASZ, FRANCIS L., Instructor in Civil Engineering, Lehigh University, Bethlehem, Pa. Hale Sutherland, M. O. Fuller.

ERIKSEN, EDWARD L., Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. H. E. Mayrose, C. J. Freund. Re-instatement.

GERMANO, FIORINO J., Instructor in Civil Engineering, Louisiana State University, Baton Rouge, La. L. J. Lassalle, F. H. Fenn.

HOLMES, LYNN C., Instructor in Electrical Engineering and Physics, Rensselaer Polytechnic Institute, Troy, N. Y. J. G. Fairfield, S. B. Wiltse.

KESSLER, LEWIS H., Assistant Professor of Hydraulics and Sanitary Engineerneering, University of Wisconsin, Madison, Wis. F. M. Dawson, F. E. Turneaure.

MILLER, LORIN G., Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich. W. E. Reuling, H. B. Dirks.

MILLS, LAWRENCE W., Assistant Dean, Case School of Applied Science, Cleveland, Ohio. T. M. Focke, W. E. Wickenden.

NUGENT, HOMER H., Professor of Rhetoric, Rensselaer Polytechnic Institute, Troy, N. Y. S. B. Wiltse, J. G. Fairfield.

PRIOR, THOBURN W., Personnel Dept., Goodyear Tire & Rubber Co., Akron, Ohio. John Bangs, J. Walters.

ROBBINS, JAMES M., Assistant Professor of Civil Engineering, Newark College of Engineering, Newark, N. J. R. W. VanHouten, H. N. Cummings.

SCHOONOVER, REX H., Associate Professor of Engineering Mechanics, Wayne University, Detroit, Mich. D. L. Perkins, R. T. Northrup.

SLOAN, WILLIAM A., Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. G. E. Crofoot, C. D. Fawcett.

TSCHEBOTAREFF, GREGORY P., Lecturer in Civil Engineering, Princeton University, Princeton, N. J. A. M. Greene, F. H. Constant.

TUCKER, SAMUEL M., Professor of English, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. H. P. Hammond, H. S. Rogers.

WESTERGAARD, HARALD M., Gordon MacKay Professor of Civil Engineering (Sept. 1, 1937, Dean, Graduate School of Engineering)), Harvard University, Cambridge, Mass. J. P. DenHartog, H. J. Gilkey.

WOERNER, WILLIAM C., Assistant Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis. B. G. Elliott, G. L. Larson.

231 new members, May 27, 1937.

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G-E *Campus News*

"EXPERIMENTALLY—NOT ON PAPER"

SIXTEEN years or so ago, Dr. Willis R. Whitney, now Vice President in charge of General Electric research, sent a note to a research worker, suggesting experiments with a motor-generator set sealed gastight and filled with hydrogen to see if the machine ran cooler, and more efficiently. The results of those experiments promoted the use of hydrogen in synchronous condensers and established the present trend toward the use of hydrogen in turbine-generators.

Windage loss in a rotating machine is reduced about 90 per cent and noise is greatly decreased because of the low density of hydrogen. Heat is carried away much more rapidly through the higher thermal conductivity of hydrogen. Resistance to damage due to corona within the machine is increased. These characteristics increase the electrical output for a given core size and reduce inspection and maintenance expense.

The construction of several hydrogen-cooled turbine-generating units is now going on in the Schenectady turbine shop—perhaps all because of that note written by Dr. Whitney so many years ago.

FOR OUTSTANDING ACHIEVEMENT

FEBRUARY 26 was a big day in the lives of thirty-three G-E employees. These thirty-three were selected from the 60,000 persons in the Company's employ to receive the Charles A. Coffin Awards. There were fifteen factory men, twelve engineers, two commercial men, and four administrative and clerical employees. Twelve of the group are college graduates:

Roy T. Adolphson, University of Washington, '34; Eugene W. Boehne, Texas A & M, '26 and M. I. T., '28; Claude P. Hamilton, University of Nevada, '14; George H. Jump, Syracuse U., '10; Jack R. Meador, Texas A & M, '27 and '28; Harry E. Scarbrough, Georgia Tech., '19; Edward J. Schaefer, Johns Hopkins, '23; Alfred A. Thompson, University of California, '05; Carl Thumin, College of City of New York, '17, M. I. T., '20; Harold E. Trekell, Kansas State, '31; Elmer J. Wade, University of Maine, '19; and Leo F. Worden, West Virginia University, '25.

Each year General Electric makes these awards to employees who have done outstanding work, as provided in the Charles A. Coffin Foundation established in 1922. Charles A. Coffin was organizer and first president of General Electric.

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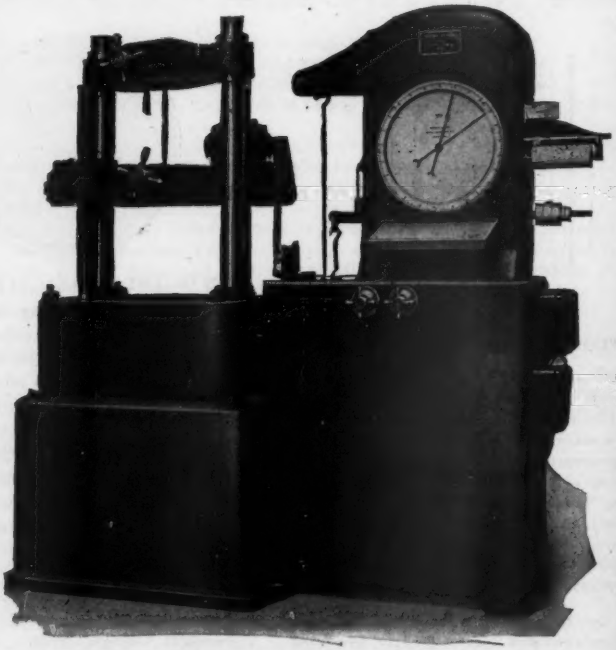

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THE JOURNAL OF ENGINEERING EDUCATION

ublished by THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

A Summary of Reports Concerning the Committee on Engineering Schools of the ngineers' Council for Professional Development

I. Engineers' Council for Professional Development: Organization and Accrediting Program.

II. Report to the Society for the Promotion of Engineering Education.

II. List of Accredited Curricula offered by Colleges in Regions I and II.

/. Program of Committee on Engineering Schools for 1936–1937.

Supplement to

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I

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

Organization and Program

Engineers' Council for Professional Development was organized in 1932 for the express purpose of improving the status of the engineering profession. To this end the Council has inaugurated a program dealing with the selection, guidance, training and certification of the members of the profession. This program is being carried out under the direction of four operating committees. One of these, the Committee on Engineering Schools, is expected, as part of its broad purpose of assisting in the enhancement of the status of engineering education "to formulate criteria for colleges of engineering, which will insure to their graduates a sound educational background for practicing the engineering profession." A specific duty assigned to the committee is the inspection of engineering colleges with a view to the accrediting of curricula offered by them.

After a thorough study of accrediting methods of other agencies the committee formulated a statement of principles and a procedure in accordance with which its program would be carried out. This program was inaugurated in November, 1935. Since then the first stage of the work has been virtually completed and was reported upon by the committee to the Annual Meeting of E. C. P. D., held on October 6, 1936.

The accrediting program is being conducted under authorization to function as the agency of the several groups constituting E. C. P. D.: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

The statement of principles in accordance with which recommendations as to accrediting are prepared is as follows:

Basis for Accrediting

1. Purposes of accrediting shall be to identify those institutions which offer professional curricula in engineering worthy of recognition as such.

2. Accrediting shall apply only to those curricula which lead to degrees.

3. Both undergraduate and graduate curricula shall be accredited. (Accrediting of graduate curricula deferred until a later date.)

4. Curricula in each institution shall be accredited individually. For this purpose, E. C. P. D. will recognize the six major curricula: Chemical, Civil, Electrical, Mechanical, Metallurgical, and Mining Engineering—represented in its own organization, and such other curricula as are warranted by the educational and industrial conditions pertaining to them.

5. Curricula shall be accredited on the basis of both qualitative and quantitative criteria.

6. Qualitative criteria shall be evaluated through visits of inspection by a committee or committees of qualified individuals representing E. C. P. D.

7. Quantitative criteria shall be evaluated through data secured from catalogues and other publications, and from questionnaires.

8. Qualitative criteria shall include the following:

I. Qualifications, experience, intellectual interests, attainments and professional productivity of members of the faculty.
II. Standards and quality of instruction.
    a. In the engineering departments.
    b. In the scientific and other coöperating departments in which engineering students receive instruction.
III. Scholastic work of students.
IV. Records of graduates both in graduate study and in practice.
V. Attitude and policy of administration towards its engineering division and toward teaching, research and scholarly production.

9. Quantitative criteria shall include the following:

I. Auspices, control and organization of the institution and of the engineering division.
II. Curricula offered and degrees conferred.
III. Age of the institution and of the individual curricula.
IV. Basis of and requirements for admission of students.
V. Number of students enrolled.
    a. In the engineering college or division as a whole.
    b. In the individual curricula.
VI. Graduation requirements.
VII. Teaching staff and teaching loads.
VIII. Physical facilities. The educational plant devoted to engineering education.
IX. Finances: investments, expenditures, sources of income.

The purpose of E. C. P. D. is to substitute a single accrediting for the uncoördinated methods that have been used in the past. E. C. P. D., representing the national engineering societies, the state licensing boards, and the colleges of engineering, is the only agency that can accredit colleges under properly inclusive auspices. As a not unimportant incidental advantage, accrediting by this one agency will avoid the needless duplications of present procedures.

E. C. P. D. is merely authorized by its constituent organizations to publish a list of accredited colleges for use by those agencies which require such a list. It has no authority to impose any restrictions or standardizations upon engineering colleges, nor does it desire to do so. On the contrary, it aims to preserve the independence of action of individual institutions and to promote the general advancement of engineering education thereby.

Accrediting of curricula offered by institutions will be upon invitation of the institution.

Final decision as to accrediting of each institution rests with the Engineers' Council for Professional Development which will pass upon the recommendations made to it by the Committee on Engineering Schools.

The membership of the E. C. P. D. Committee on Engineering Schools comprises the following individuals:

Karl T. Compton, Massachusetts Institute of Technology, *Chairman*, representing American Institute of Electrical Engineers.

H. P. Hammond, Polytechnic Institute of Brooklyn, *Vice Chairman*, representing Society for the Promotion of Engineering Education.

G. M. Butler, University of Arizona, representing American Institute of Mining and Metallurgical Engineers.

Ivan C. Crawford, University of Idaho, representing American Society of Civil Engineers.

Harry A. Curtis, Tennessee Valley Authority, representing American Institute of Chemical Engineers.

P. H. Daggett, Rutgers University, representing National Council of State Boards of Engineering Examiners.

A. A. Potter, Purdue University, representing American Society of Mechanical Engineers.

II

REPORT TO THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

As one of the representatives of the Society for the Promotion of Engineering Education on E. C. P. D., Professor H. P. Hammond made the following report on the accrediting program to the Society at the 44th Annual Meeting at the University of Wisconsin, June 22–26, 1936.

"During the year the work of the Committee has been devoted entirely to the program of accrediting of undergraduate curricula of degree-conferring engineering schools. Thus far the program of inspection has been confined to two of the seven regions into which the country has been divided: Region I, the New England States; and Region II, the Middle States and Maryland. It was in these two regions that E. C. P. D. was authorized by its constituent societies to launch its accrediting program on a trial basis before inaugurating it in other sections of the country.

"The program was launched in June, 1935, by letter of notification advising the degree-conferring institutions in the two regions that E. C. P. D. was prepared, upon invitation, to appraise undergraduate curricula with a view to accrediting. The basis of evaluation and the principles upon which lists of accredited curricula would be prepared, as well as the procedures to be followed in visiting and inspecting the institutions, have been reported to the Society previously at the Atlanta meeting.

"The first stage of the accrediting program has now been virtually completed so far as the visits of inspection and evaluation of statistical information is concerned in Regions I and II. Forty institutions in these regions have applied for consideration of their undergraduate curricula and all but one of which have now been visited, that one having submitted its application so late that the visit has been postponed to next autumn. All but four of the degree-conferring schools of these regions are included in the forty. Of the remaining four, two are in New England and two in the Middle States and Maryland. One of these does not offer undergraduate curricula and hence does not fall within the scope of the program; one offers a single curriculum in a special field; and one, it is understood, is merely deferring action.

"The first visits of inspection were made in November, 1935, by the full membership of the Committee on Engineering Schools. Early in 1936 the two regional committees were organized and began their work. The last visits were made in May and complete reports on all schools and curricula have now been prepared. The membership of the two Committees is as follows:

Region I, New England

"Representing the Society for the Promotion of Engineering Education: D. C. Jackson,* R. E. Doherty, G. W. Case.

"Representing the American Society of Civil Engineers: G. W. Case and C. W. Sherman.

"Representing the American Institute of Electrical Engineers: D. C. Jackson,* R. E. Doherty, E. L. Moreland.

"Representing the American Society of Mechanical Engineers: S. W. Dudley, H. R. Westcott.

"Representing the American Institute of Mining and Metallurgical Engineers: C. H. Mathewson and G. B. Waterhouse.

"Representing the American Institute of Chemical Engineers: B. F. Dodge and W. G. Whitman.

"H. P. Hammond, Chairman: representing the National Council of State Boards of Engineering Examiners; Member, E. C. P. D. Committee on Engineering Schools.

Region II, Middle States and Maryland

"Representing the S. P. E. E.: D. S. Kimball, E. A. Holbrook, Louis Mitchell.

"Representing Am. Soc. C. E.: Louis Mitchell, J. P. H. Perry, J. K. Finch.

"Representing A. S. M. E.: E. F. Church, Jr., D. S. Kimball, Herman Diederichs.

"Representing A. I. E. E.: A. M. Dudley, O. W. Eshbach.

"Representing A. I. M. E.: E. A. Holbrook and T. T. Read.

"Representing A. I. Ch. E.: H. C. Parmelee, W. N. Jones, A. B. Newman.

"Representing N. C. S. B. E. E.: J. W. Barker, F. O. X. McLoughlin.

"Karl T. Compton, Chairman: Member, E. C. P. D. Committee on Engineering Schools.

"Reports prepared by these committees will be considered by the Committee on Engineering Schools at a meeting to be held on June 26 to 28, 1936, inclusive, and final recommendations will be prepared at that meeting for presentation to E. C. P. D., presumably at its annual meeting in October, 1936. These recommendations will take one of the following forms:

"1. To include the curriculum in question on the E. C. P. D. list of accredited curricula.

"2. To defer action, or to include the curriculum on the list when, or if, improvements are effected.

"3. Not to include the curriculum on the list. It is expected that the E. C. P. D. list of accredited curricula of institutions in Regions I and II will be made public shortly after the October meeting. Until then the results of the work to date cannot be made known.

"As a particular phase of the procedure to date it should be explained that recommendations as to curricula in Chemical Engineering based upon reports of the representatives listed above will be submitted to the Committee on Engineering Schools of E. C. P. D. by the Committee on Chem-

* Professor Jackson was out of the country during the past year and was therefore not able to participate in any of the accrediting program.

ical Engineering Education of the American Institute of Chemical Engineers. All visits of inspection of curricula not previously accredited by A. I. Ch. E. were made concurrently with the general inspections of other curricula and the committees have functioned throughout as a single unit in each region. The Committee on Engineering Schools is recommending to E. C. P. D. for inclusion in its list of accredited curricula all curricula in Chemical Engineering previously approved by the American Institute of Chemical Engineers.

"The program of accrediting in the other five regions was launched within the past two months in the same manner as in Regions I and II, by notification to the institutions that upon invitation E. C. P. D. is prepared to consider curricula submitted with a view to accrediting. Active prosecution of the program will begin in the autumn. Institufions in Regions I and II that have not previously invited inspection will also be considered during the next academic year upon their request. It is expected that the first comprehensive stage of E. C. P. D. program will be completed by June, 1937, and that the list of accredited curricula for all regions will be published by October of that year.

"In concluding this report it may be of interest briefly to summarize certain results and impressions of the accrediting program as conducted thus far:

"Of primary importance to the general welfare of engineering education, it is evident that the accrediting program can be, and has been thus far, of direct benefit in bringing about improvements in a considerable number of the institutions. These benefits have resulted from recommendations, based upon the inspection and evaluation of assembled data, looking to improvements or additions to staff or facilities, changes in curricula, etc. In some instances such changes or improvements have been made a definite condition precedent to the submission of a favorable report on accrediting. In others they have been made as the result of informal suggestions and recommendations. In either case the recommendations have had prompt and, in some cases, salutary results. In every case we believe they have been constructive.

"It is our belief also that the basis of valuation, which is largely founded on appraisal of quality of work and of standards rather than on fixed quantitative criteria, and is thereby more difficult to apply than the older and more rigidly limiting basis of valuation, has, nevertheless, provided the means of making accurate valuations. We feel that the list of accredited curricula, when published, will be recognized as a properly discriminating one."

III

LIST OF ACCREDITED CURRICULA OFFERED BY COLLEGES IN REGIONS I AND II

The following list of accredited curricula was adopted by Engineers' Council for Professional Development, on recommendation of the Committee on Engineering Schools, at its meeting of

October 6, 1936. Three institutions in Regions I and II made application to E. C. P. D. for consideration of their curricula at such a late date that inspections could not be made prior to the meeting at which the following list was adopted. Curricula of these institutions and of any others in these regions that may apply in the near future will be considered during the current academic year and such of their curricula as may be accredited will be published with the list to appear in the fall of 1937.

List of Accredited Undergraduate Curricula

(*A*) Arranged by Institutions
(*B*) Arranged by Curricula

(*as of 1936 and subject to continual revision*)

Includes institutions in the following states only: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

(*A*) *Arranged by Institutions*

1. Brown University	Civil Engineering
	Electrical Engineering
	Mechanical Engineering
2. Carnegie Institute of Technology	Chemical Engineering (*e*)
	Civil Engineering (*a*)
	Electrical Engineering (*a*)
	Management Engineering (*a*)
	Mechanical Engineering (*a*)
	Metallurgical Engineering (*a*)
3. Clarkson College of Technology	Civil Engineering
	Electrical Engineering
	Mechanical Engineering
4. College of the City of New York	Civil Engineering (*a*)
	Electrical Engineering (*a*)
5. Columbia University	Chemical Engineering (*b*)
	Civil Engineering (*b*)
	Electrical Engineering (*b*)
	Industrial Engineering (*b*)
	Mechanical Engineering (*b*)
	Metallurgical Engineering (*b*)
	Mining Engineering (*b*)
6. Cooper Union Institute of Technology	Civil Engineering (*c*)
	Electrical Engineering (*c*)
	Mechanical Engineering (*c*)
7. Cornell University	Administrative Engineering
	Chemical Engineering
	Civil Engineering
	Electrical Engineering
	Mechanical Engineering
8. Dartmouth College	Civil Engineering
9. University of Delaware	Civil Engineering
	Electrical Engineering
	Mechanical Engineering

10. Drexel Institute	Chemical Engineering (*d*)
	Civil Engineering (*d*)
	Electrical Engineering (*d*)
	Mechanical Engineering (*d*)
11. Johns Hopkins University	Civil Engineering
	Electrical Engineering
	Mechanical Engineering
12. Lafayette College	Civil Engineering
	Electrical Engineering
	Mechanical Engineering (Technical Option)
	Metallurgical Engineering
	Mining Engineering
13. University of Maine	Civil Engineering
	Electrical Engineering
	General Engineering
	Mechanical Engineering
14. Massachusetts Institute of Technology	Aeronautical Engineering
	Architectural Engineering
	Business and Engineering Administration
	Chemical Engineering
	Civil Engineering
	Electrical Engineering
	Electrochemical Engineering
	General Engineering
	Mechanical Engineering
	Metallurgy
	Mining Engineering
	Naval Architecture and Marine Engineering
	Sanitary Engineering
15. University of New Hampshire	Civil Engineering
	Electrical Engineering
	Mechanical Engineering
16. New York University	Aeronautical Engineering (*c*)
	Chemical Engineering
	Civil Engineering (*c*)
	Electrical Engineering (*c*)
	Mechanical Engineering (*c*)
17. Newark College of Engineering	Civil Engineering
	Electrical Engineering
	Mechanical Engineering
18. Norwich University	Civil Engineering
	Electrical Engineering
19. Pennsylvania State College	Architectural Engineering
	Chemical Engineering
	Civil Engineering
	Electrical Engineering
	Electrochemical Engineering
	Industrial Engineering
	Mechanical Engineering
	Sanitary Engineering

20. University of Pittsburgh	Chemical Engineering Civil Engineering Electrical Engineering Industrial Engineering Mechanical Engineering Metallurgical Engineering Mining Engineering Petroleum Engineering
21. Polytechnic Institute of Brooklyn	Chemical Engineering (*e*) Civil Engineering (*a*) Electrical Engineering (*a*) Mechanical Engineering (*a*)
22. Princeton University	Chemical Engineering Civil Engineering Electrical Engineering Mechanical Engineering
23. Rensselaer Polytechnic Institute	Chemical Engineering Civil Engineering Electrical Engineering Mechanical Engineering
24. Rhode Island State College	Civil Engineering Electrical Engineering Mechanical Engineering
25. University of Rochester	Mechanical Engineering
26. Rutgers University	Civil Engineering Electrical Engineering Mechanical Engineering Sanitary Engineering
27. Stevens Institute of Technology	General Engineering
28. Swarthmore College	Civil Engineering Electrical Engineering Mechanical Engineering
29. Syracuse University	Civil Engineering Electrical Engineering Mechanical Engineering
30. Tufts College	Civil Engineering Electrical Engineering Mechanical Engineering
31. Union College	Civil Engineering Electrical Engineering
32. University of Vermont	Civil Engineering Electrical Engineering Mechanical Engineering
33. Webb Institute of Naval Architecture	Naval Architecture and Marine Engineering
34. Worcester Polytechnic Institute	Civil Engineering Electrical Engineering Mechanical Engineering
35. Yale University	Chemical Engineering Civil Engineering Electrical Engineering Mechanical Engineering Metallurgical Engineering

(*B*) *Arranged by Curricula*

Aeronautical Engineering
- Massachusetts Institute of Technology
- New York University (*c*)

Architectural Engineering
- Massachusetts Institute of Technology
- Pennsylvania State College

Chemical Engineering (*f*)
- Carnegie Institute of Technology (*c*)
- Columbia University (*b*)
- Cornell University
- Drexel Institute (*d*)
- Massachusetts Institute of Technology
- New York University
- Pennsylvania State College
- University of Pittsburgh
- Polytechnic Institute of Brooklyn (*c*)
- Princeton University
- Rensselaer Polytechnic Institute
- Yale University

Civil Engineering
- Brown University
- Carnegie Institute of Technology (*a*)
- Clarkson College of Technology
- College of the City of New York (*a*)
- Columbia University (*b*)
- Cooper Union Institute of Technology (*c*)
- Cornell University
- Dartmouth College
- University of Delaware
- Drexel Institute (*d*)
- Johns Hopkins University
- Lafayette College
- University of Maine
- Massachusetts Institute of Technology
- University of New Hampshire
- New York University (*c*)
- Newark College of Engineering
- Norwich University
- Pennsylvania State College
- University of Pittsburgh
- Polytechnic Institute of Brooklyn (*a*)
- Princeton University
- Rensselaer Polytechnic Institute
- Rhode Island State College
- Rutgers University
- Swarthmore College
- Syracuse University
- Tufts College
- Union College
- University of Vermont
- Worcester Polytechnic Institute

Yale University

Electrical Engineering

Brown University
Carnegie Institute of Technology (*a*)
Clarkson College of Technology
College of the City of New York (*a*)
Columbia University (*b*)
Cooper Union Institute of Technology (*c*)
Cornell University
University of Delaware
Drexel Institute (*d*)
Johns Hopkins University
Lafayette College
University of Maine
Massachusetts Institute of Technology
University of New Hampshire
New York University (*c*)
Newark College of Engineering
Norwich University
Pennsylvania State College
University of Pittsburgh
Polytechnic Institute of Brooklyn (*a*)
Princeton University
Rensselaer Polytechnic Institute
Rhode Island State College
Rutgers University
Swarthmore College
Syracuse University
Tufts College
Union College
University of Vermont
Worcester Polytechnic Institute
Yale University

Electrochemical Engineering

Massachusetts Institute of Technology
Pennsylvania State College

General Engineering

University of Maine
Massachusetts Institute of Technology
Stevens Institute of Technology

Industrial Engineering

Carnegie Institute of Technology (Management Engineering) (*a*)
Columbia University (*b*)
Cornell University (Administrative Engineering)
Massachusetts Institute of Technology (Business and Engineering Administration)
Pennsylvania State College
University of Pittsburgh

Mechanical Engineering

Brown University
Carnegie Institute of Technology (*a*)
Clarkson College of Technology
Columbia University (*b*)
Cooper Union Institute of Technology (*c*)

Cornell University
University of Delaware
Drexel Institute (*d*)
Johns Hopkins University
Lafayette College (Technical Option)
University of Maine
Massachusetts Institute of Technology
University of New Hampshire
New York University (*c*)
Newark College of Engineering
Pennsylvania State College
University of Pittsburgh
Polytechnic Institute of Brooklyn (*a*)
Princeton University
Rensselaer Polytechnic Institute
Rhode Island State College
University of Rochester
Rutgers University
Swarthmore College
Syracuse University
Tufts College
University of Vermont
Worcester Polytechnic Institute
Yale University

Metallurgical Engineering

Carnegie Institute of Technology (*a*)
Columbia University (*b*)
Lafayette College
Massachusetts Institute of Technology (Metallurgy)
University of Pittsburgh
Yale University

Mining Engineering

Columbia University (*b*)
Lafayette College
Massachusetts Institute of Technology
University of Pittsburgh

Naval Architecture and Marine Engineering

Massachusetts Institute of Technology
Webb Institute of Naval Architecture

Petroleum Engineering

University of Pittsburgh

Sanitary Engineering

Massachusetts Institute of Technology
Pennsylvania State College
Rutgers University

Explanatory Notes

Note: Following is a list of specialized curricula upon which action has been deferred pending completion of the accrediting program throughout the country:

Building Engineering and Construction
Gas Engineering
Mineral Dressing
Paper and Pulp Technology
Petroleum Refining
Public Health Engineering

E. C. P. D. also has under consideration at this time curricula at certain institutions in these states for which the sub-committees of inspection are not yet prepared to submit specific recommendations with regard to accrediting. It is expected that these recommendations will be ready for action by the Council early in 1937.

Footnotes:

(*a*) Accrediting applies to both the day and evening curricula.

(*b*) Accrediting applies to the four-year and five-year curricula leading to the Bachelor of Science Degree.

(*c*) Accrediting applies to day curriculum only. Action on evening curricula in which the quantitative requirements differ materially from the usual day curricula has been deferred pending further study by a special sub-committee of the E. C. P. D. Committee on Engineering Schools.

(*d*) Accrediting applies to the five-year coöperative curriculum.

(*e*) E. C. P. D. has not received from its sub-committee on Chemical Engineering any recommendations with respect to evening curricula in chemical engineering.

(*f*) Institutions offering several curricula in engineering and for which E. C. P. D. has received recommendations only in respect to chemical engineering have not been included in this preliminary list.

IV

PROGRAM OF COMMITTEE ON ENGINEERING SCHOOLS FOR 1936–1937

In accordance with authorization given by its constitutent bodies E. C. P. D., through its Committee on Engineering Schools, will continue the work of visiting engineering colleges during the current academic year and expects to complete the major portion of its program before the close of the year. Institutions in Regions III to VII inclusive were notified in March, 1936, that E. C. P. D. was prepared, upon invitation, to visit and inspect the schools with a view to considering curricula submitted for accrediting. Of the 109 institutions in these regions that are known to confer degrees in engineering, 61 had requested inspection by September 1st, 1936, making 103 institutions in all—including those in Regions I and II—that have submitted requests. Visits to these institutions will be made during the year, beginning about November 1st or shortly thereafter. During the same period institutions in Regions I and II whose requests for investigation were received too late for consideration last year will also be considered. It is expected that a list of accredited curricula covering all the institutions in the country that have applied to E. C. P. D. will be published in the fall of 1937.

The following lists give the names of the members of all delegatory committees of E. C. P. D.

Requests for further information as to E. C. P. D.'s work in the accrediting program should be addressed to H. H. Henline,

Secretary, Engineers' Council for Professional Development, 29 West 39th Street, New York, N. Y.

Personnel of Committees of Inspection

American Society of Civil Engineers

G. W. Case, University of New Hampshire, Durham, N. H.
L. E. Conrad, Kansas State College, Manhattan, Kans.
H. S. Crocker, Cons. Engineer, Denver, Colo.
G. J. Davis, University of Alabama, Tuscaloosa, Ala.
Donald Derickson, Tulane University, New Orleans, La.
N. W. Dougherty, University of Tennessee, Knoxville, Tenn.
C. L. Eckel, University of Colorado, Boulder, Colo.
Joseph Jacobs, Cons. Engineer, Seattle, Wash.
Anson Marston, Iowa State College, Ames, Ia.
Louis Mitchell, Syracuse University, Syracuse, N. Y.
C. A. Mockmore, Oregon State College, Corvallis, Ore.
J. P. H. Perry, Turner Construction Co., New York, N. Y.
C. W. Sherman, Metcalf & Eddy, Boston, Mass.
R. B. Wiley, Purdue University, Lafayette, Ind.

American Institute of Mining and Metallurgical Engineers

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Jay A. Carpenter, Mackay School of Mines, Reno, Nev.
J. R. Cudworth, University of Alabama, Tuscaloosa, Ala.
D. J. Demorest, Ohio State University, Columbus, O.
C. H. Fulton, Missouri School of Mines, Rolla, Mo.
E. A. Holbrook, University of Pittsburgh, Pittsburgh, Pa.
C. E. Lawall, West Virginia University, Morgantown, W. Va.
Robert S. Lewis, University of Utah, Salt Lake City, Utah
C. H. Mathewson, Yale University, New Haven, Conn.
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Milnor Roberts, University of Washington, Seattle, Wash.
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C. M. Young, University of Kansas, Lawrence, Kans.

American Society of Mechanical Engineers

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A. J. Dickie, Pacific Marine Review, San Francisco, Calif.
S. W. Dudley, Yale University, New Haven, Conn.
S. B. Earle, Clemson Agricultural College, Clemson College, S. C.
J. H. Felgar, Univ. of Oklahoma, Norman, Okla.
J. W. Haney, University of Nebraska, Lincoln, Neb.
W. A. Hanley, Eli Lilly & Co., Indianapolis, Ind.
Dexter S. Kimball, Cornell University, Ithaca, N. Y.
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C. F. Harding, Purdue University, Lafayette, Ind.
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W. G. Whitman, Massachusetts Institute of Technology, Cambridge, Mass.
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